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ON THE MINUTE MEASUREMENTS OF MODERN SCIENCE.

By Alfred M. Mayer.

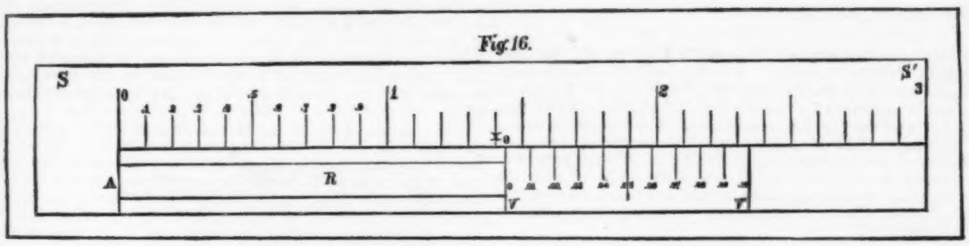
Article VII.

ON THE VERNIER AND THE VERNIER MICROSCOPE.

The vernier is a very ingenious invention, which subdivides the smallest divisions on a scale, and thus does away with the necessity of directly dividing these smallest divisions, by drawing in them fine equidistant lines. Another advantage of the vernier is that we can far more readily see and read subdivisions made by its aid than equally small divisions directly made by fine equidistant lines.

The vernier derives its name from Pierre Vernier, a Frenchman, who invented it, and first described his invention in a book entitled, "La Construction, l'usage et les propriétés du cadran nouveau," Bruxelles, 1631. A vernier is often improperly called a *nonius*, after Nunez, a Portuguese astronomer; but the invention of Nunez is quite different.

By the aid of the accompanying figures, the nature of the vernier, and the manner of using it, may be clearly explained. In Fig. 16 is shown a scale, S S', divided into three units, from 0 to 3. Each of these units is subdivided into ten parts. V V' is the vernier. It consists of a scale which slides along the main scale, and is constructed as follows: Nine of the tenths on the main, or fixed scale, are taken as the length of the whole vernier scale; then this length of $\frac{9}{10}$ths is divided into ten parts, and we have the vernier of our drawing. From the above construction it follows that each division on the vernier is $\frac{1}{10}$th of $\frac{9}{10}$ths, or $\frac{9}{100}$ths of a unit, on the main scale; while each smallest division on the main scale is $\frac{1}{10}$th of a unit; hence each division on the vernier is smaller than a division on the main scale by $\frac{1}{10}$th minus $\frac{9}{100}$; or, what is the same thing, by $\frac{10}{100}$ths minus $\frac{9}{100}$ths, which equals $\frac{1}{100}$th of a unit. The reader will now understand why the divisions on the vernier are designated as hundreths, being numbered ·0, ·01, ·02, ·03, etc.



THE VERNIER SCALE.

Looking at the line marked ·04, the reader will observe that it coincides with the $\frac{8}{10}$th line of the 2d unit on the main scale. This being the case, it necessarily follows that the ·03 line on the vernier is separated from the $\frac{7}{10}$th line on the scale by $\frac{1}{100}$th of a unit; that the ·02 line on the vernier is separated from the $\frac{6}{10}$th line on the scale by $\frac{2}{100}$ths of a unit of the main scale; that the ·01 line on the vernier is distant from the $\frac{5}{10}$th line on the scale by $\frac{3}{100}$ths of a unit, and finally, that the ·00 line on the vernier is separated from the $\frac{4}{10}$th line on the scale by $\frac{4}{100}$ths of a unit. This being clearly understood, we can at once make a measure with the vernier to $\frac{1}{100}$th of a unit.

Let R represent a metallic rod whose length we wish to know. Its end is placed against the abutting plate A, whose edge is a continuation of the zero line of the main scale. The vernier is now slid down on to the other end of the rod, as shown in the Figure. The length of the rod is now read off on the main scale as one unit and $\frac{4}{10}$ths of a unit, and a fraction of a tenth (from x to 0) over. The fraction of a tenth we can only obtain from the vernier, and we have just shown that this fraction is $\frac{4}{100}$ths of a unit; hence the length of the rod is 1 unit, $\frac{4}{10}$ths, and $\frac{4}{100}$ths; or, adding these quanties together, its length is 1 and $\frac{44}{100}$ths; or, exexpressed decimally, 1·44.

If the reader will paste Fig. 16 (or any of the other Figures) on a thin board, and then cut the vernier, with the board, free from the main scale, and then cut a clean edge along the main scale, he can place the zero of the vernier to various points on the main scale, and practice reading it at various "settings." The method of reading this vernier is very simple. The units and tenths are taken from the main scale, the hundredths are obtained by running the eye up the vernier till it comes to the number on that line on the vernier which coincides with a line on the main scale.

We have given this special and simple example of the vernier because it is the vernier that is generally used on the ordinary mercurial barometer. If we suppose that the unit on the scale of Fig. 16 is one inch, then the reading becomes one inch and $\frac{44}{100}$ths of an inch.

The general rule for constructing any vernier is not difficult to understand, provided the reader will give the subject a little reflection. It is as follows: Call any whole number, n. Then, to make a vernier which shall read to the nth part of the smallest division on the main scale, we make n divisions on the vernier equal $n + 1$; or, $n - 1$ divisions on the main scale. Thus, to make a vernier to read to tenths of a tenth, as in the example just given, we have n equal to 10; and $n \times 1$ and $n - 1$, equal respectively 11 and 9. We took $n - 1$, or 9 divisions on the main scale, and then divided this length into n, or 10 parts. This evidently gives us a vernier which reads to the nth part, or $\frac{1}{10}$th, of the smallest divisions on the scale; the latter are tenths of a unit, hence the vernier reads to $\frac{1}{10}$th of $\frac{1}{10}$th, or to $\frac{1}{100}$th of a unit.

If we desired to construct a vernier on a barometer to read to $\frac{2}{1000}$ths, or to $\frac{1}{500}$ths of an inch, we would first divide each inch on the barometer scale into 20 parts. Then we should take 26 of these twentieths of an inch for the whole length of the vernier; and on dividing this length into 25 equal parts, we would have a vernier each of whose divisions will be $\frac{1}{25}$th of the $\frac{1}{20}$th of an inch, or $\frac{1}{500}$th of an inch shorter than a twentieth of an inch on the main scale. In this example the nth part of a division on the main scale must be $\frac{1}{25}$th. To obtain a vernier reading to the $\frac{1}{25}$th, we must take $n + 1$, or 26, or $n - 1$, or 24 of the smallest divisions, or twentieths of inches, from the main scale as the length of our vernier. We then divide this length into n, or 25 parts. This gives a vernier reading to $\frac{2}{1000}$ths of an inch. In Fig. 17 a vernier, similar to the one just described, is shown attached to a barometer.

It is very important in these days of refined construction for engineers and mechanists to have *a handy rule for reading any vernier at sight*. Here is one: *The smallest subdivision by the vernier of the fractions on the main scale is obtained by dividing the value of the smallest divisions on the main scale by the number of divisions on the vernier.*

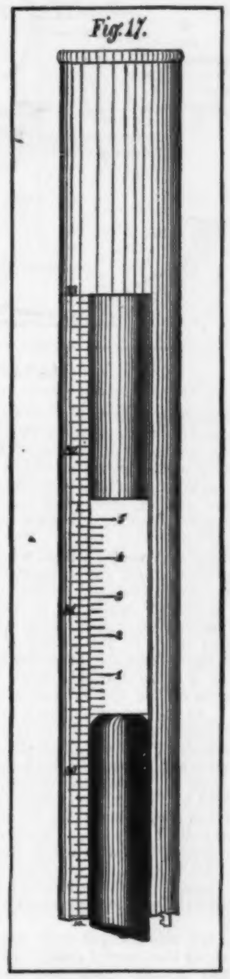
By applying this rule for vernier reading to the various figures of verniers accompanying this article, the reader will appreciate its practical value.

We will first apply the rule to the vernier on Brown & Sharpe's vernier-callipers, an instrument now in the hands of many mechanics. Looking at the main scale, we soon ascertain that each inch on it is divided into 40 parts. Looking at the vernier, we find that it contains 25 equal parts. Hence, applying the rule—$\frac{1}{25}$th of $\frac{1}{40}$th of an inch equals $\frac{1}{1000}$th of an inch: the callipers measure down to $\frac{1}{1000}$th of an inch.

In Fig. 16, the scale is divided into tenths. On the vernier there are ten divisions; hence, $\frac{1}{10}$th of $\frac{1}{10}$ equals $\frac{1}{100}$, the smallest reading with this vernier.

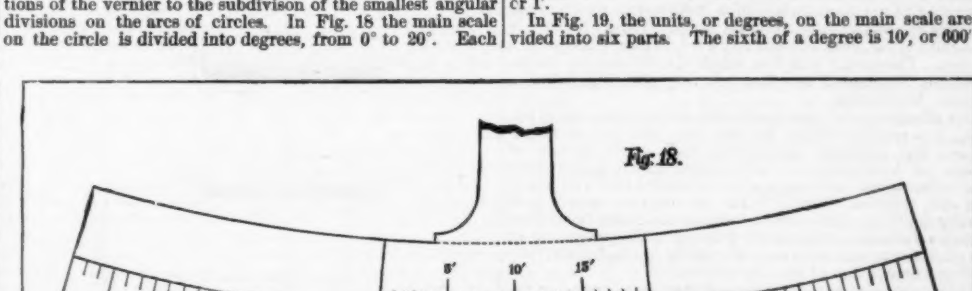
In Fig. 17, each inch or unit is divided into 20 parts. In the whole length of the vernier we count 25 divisions; hence, the vernier reads to $\frac{1}{25}$th of $\frac{1}{20}$th of an inch, or to $\frac{2}{1000}$th of an inch. The actual reading of this vernier, as shown in Fig. 17, is $30\frac{386}{1000}$, or 30·386 inches.

In Figs. 18 and 19 we have given examples of the applications of the vernier to the subdivison of the smallest angular divisions on the arcs of circles. In Fig. 18 the main scale on the circle is divided into degrees, from 0° to 20°. Each degree is subdived into *three* parts; but as a degree equals 60 minutes, it follows that $\frac{1}{3}$d of a degree is 20 minutes of arc. The lowest reading of the scale is, therefore, 20 minutes.

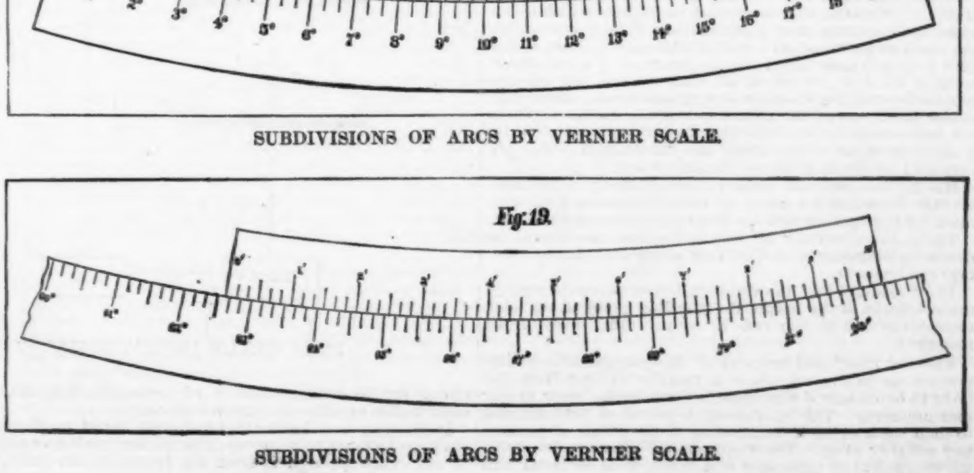


We count 20 divisions on the vernier; hence, the lowest reading by the vernier is $\frac{1}{20}$th of 20 minutes, or one minute, cr 1'.

In Fig. 19, the units, or degrees, on the main scale are divided into six parts. The sixth of a degree is 10', or 600" of



SUBDIVISIONS OF ARCS BY VERNIER SCALE.



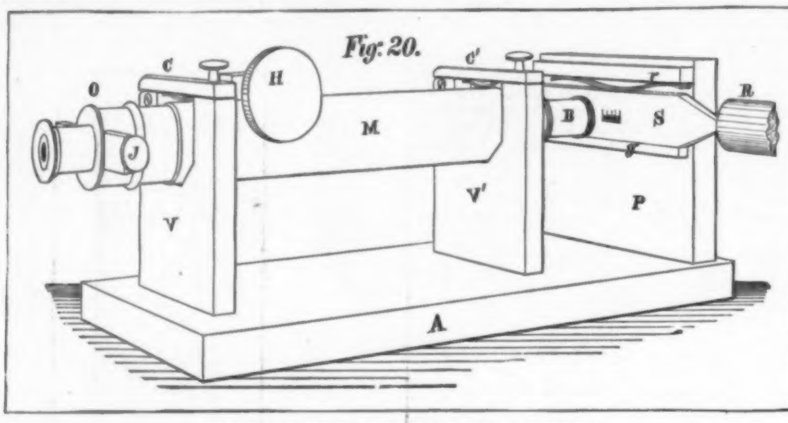
SUBDIVISIONS OF ARCS BY VERNIER SCALE.

arc. The number of divisions on the vernier is 60; hence, as the $\frac{1}{60}$th of 600″ is 10″, the smallest reading of this vernier is ten seconds of arc. This vernier, also, at the same time, gives the minutes of arc in this manner: It is divided first into ten parts, which the reader will observe designated by 0′, 1′, 2′, 3′, etc., up to 10′. Applying to these divisions the rule, we have the following result: The smallest divisions on the main scale are 10 minutes, and $\frac{1}{10}$th of 10′ equals 1′. Therefore, the main divisions on the vernier read to minutes, the secondary divisions on the vernier read to ten seconds.

We will now proceed to describe a quite recent invention of the writer, which he has named *The Vernier Microscope*, in contradistinction to the *Micrometer Microscope*, described in Article V. This invention consists in viewing through a compound microscope, a very finely and accurately divided scale cut on a glass plate, while the eye-piece of the micro scope carries another scale, on a slip of glass, which acts as a vernier to the finely divided scale on the glass plate.

Figure 20 will explain the construction and manner of the vernier microscope is the simplest instrument which is adapted to this work.

The manner of using the vernier microscope for this determination is as follows: A rod, with flat ends, is obtained of the material whose co-efficient of expansion we desire to know. This rod is inclosed in a brass tube which is so constructed that the whole length of the rod may be cooled down to the melting point of ice, or heated up to the boiling point of water, and yet the ends of the rod are exposed to the operator, so that he can embrace the whole length of the rod with his measuring apparatus. The tube carrying the rod rests in Vs, and while one end of the rod abuts against a firm abutting point, the other end is opposite the rounded end of the glass slide S. At the proper moment this glass is slid against the end of the rod R, and the vernier reading is instantly taken. This measure is repeated several times while the rod is surrounded with melting ice, at which temperature it has remained for six or eight hours. The ice is now melted from around the rod by passing steam through



MAYER'S NEW VERNIER MICROSCOPE.

using this new measuring instrument. On a matallic base, A, are firmly screwed the three upright brass plates, V, V′, and P. A a scale of thousands of inches, or of hundredths of millimeters, is cut on a glass plate, S, which slides accurately on the guide, *g*, against which it is constantly pressed by the spring, *r*. One end of this glass slide has a neatly rounded abutting point, which is shown in the figure as pressing against the end of the rod, R. The microscope, M, rests in Vs, in the plate, V and V′, into which it is firmly pressed by the springs under the clamps, C and C′. The objective, B, is accurately focussed on the scale on S, and thus a magnified image of this scale is formed directly on the scale of the vernier placed at J, in the eye-piece O. By means of the milled head, H, the ocular O may be set at greater or less distances from the objective B, and thus the magnified image of a division of the scale will occupy a greater or less length on the vernier scale at J.

As the scale at J, in the eye-piece, acts as the vernier to the magnified divisions on the scale, S, it is absolutely necessary that the length of a division on the former bears a definite and a very exact relation to the length of a division in the magnified scale S. When the divisions on the scale at S are thousandths of inches, I so adjust the distance of J from B, that 9 of the divisions on the vernier scale exactly equal 10 of the magnified divisions of thousandths of inches. This adjustment having been secured, the microscope is firmly clamped in its Vs, and the vernier is securely fixed in its slot in the eye-piece. We thus have a movable scale and a fixed vernier subdividing the scale exactly like the vernier shown in Fig. 16.

As the units on the microscopic scale are thousandths of inches, it follows that the vernier subdivides these units into tenths; that is, the vernier reads directly to $\frac{1}{10000}$ths of inches.

By using hundredths of millimeters in place of thousandths of inches, I have succeeded with a similar vernier in reading to the thousandth of a millimeter, which small quantity equals the $\frac{1}{25400}$th of an inch. This, I believe, is a magnitude far smaller than any ever before read with a vernier. The reader who has taken the trouble to understand this instrument sees that it is very properly called a Vernier Microscope.

The advantages of this instrument of precision are as follows: It is readily formed by any one who has a microscope. The ordinary micrometer scale of thousanths of inches, or hundredths of millimeters, which accompanies every microscope, may be readily converted into a slide like that at S, without injuring it for the uses to which it is usually applied; while, for the vernier at J, may be used an ordinary Jackson eye-piece micrometer. The mounting of the microscope and scale may be readily made by any one having a knowledge of the use of tools.

This instrument is much cheaper than a micrometer microscope, and when once accurately constructed it retains its accuracy; whereas, any measuring instrument which uses a screw is an instrument of precision only so long as we know the pitch and error of each part of the screw. Now, it has been very well ascertained that the errors of a screw, on account of its wear, are not at all constant, and the labor of repeatedly studying its errors is very laborious. Those difficulties in the use of the micrometer screw do not apply to our instrument, for its scales may be very accurately cut by a dividing engine whose errors are known, and which are corrected before each line of the scale is cut.

Having thus obtained scales cut as accurately as possible, we then determine the errors of their divisions and tabulate them for constant corrections to be applied to our measures.

The scale and vernier of this instrument can always be distinctly illuminated, so that very sharp and precise readings can be made.

The "readings" of the vernier microscope can be rapidly made—almost at the instant the abutting point of the slide touches the end of the rod R, or any other body to be measured.

This last mentioned property of the instrument is an important one in all work where a transfer of heat from the body to be measured will cause a considerable error in our measurements. The instrument is therefore well adapted to such work as the determination of the effects of heat on any metal or alloy. The engineer has often to determine the co-efficient of expansion of a special kind of metal, and the tube, and this current of steam is kept up till the rod ceases to increase in length. The tube with the inclosed rod is again placed in the Vs, and the increase in the length of the rod is measured by taking the difference between this measure and the previous one when the rod was cooled down to the temperature of melting ice. This important practical problem of the determination of co-efficients of expansion will be examined with some detail when we come to describe the exquisite reflecting comparator of our lamented countryman, Joseph Saxton, late of the U. S. Coast Survey Office in Washington.

IMPROVEMENT IN GENERATING ELECTRIC CURRENTS.

By ALEXANDER GRAHAM BELL, of Boston, Mass.

THIS invention consists of a method and apparatus for inducing a continuous current of electricity upon a telegraphic circuit by the rotatory motion of permanent magnets, or other bodies capable of inductive action.

It has long been known that a straight bar of magnetized steel can be made to rotate upon its axis by passing a current of electricity through it from the center to the poles, or *vice versa*. I have discovered that the converse of this is equally true; that the mechanical rotation of the bar occasions a continuous current of electricity flowing from the center of the bar to the poles, or from the poles to the center, according to the direction of the rotation.

An excited electro-magnet, or a helix of insulated wire through which a continuous current is passed, may be substituted for the permanent magnet.

A continuous current of electricity may also be induced upon a telegraphic circuit by the rotation of the conducting wire in the neighborhood of a permanent magnet, or other body capable of inductive action by the rotation of the permanent magnet in the neighborhood of the conducting wire, or by the revolution of the permanent magnet and conducting wire around each other.

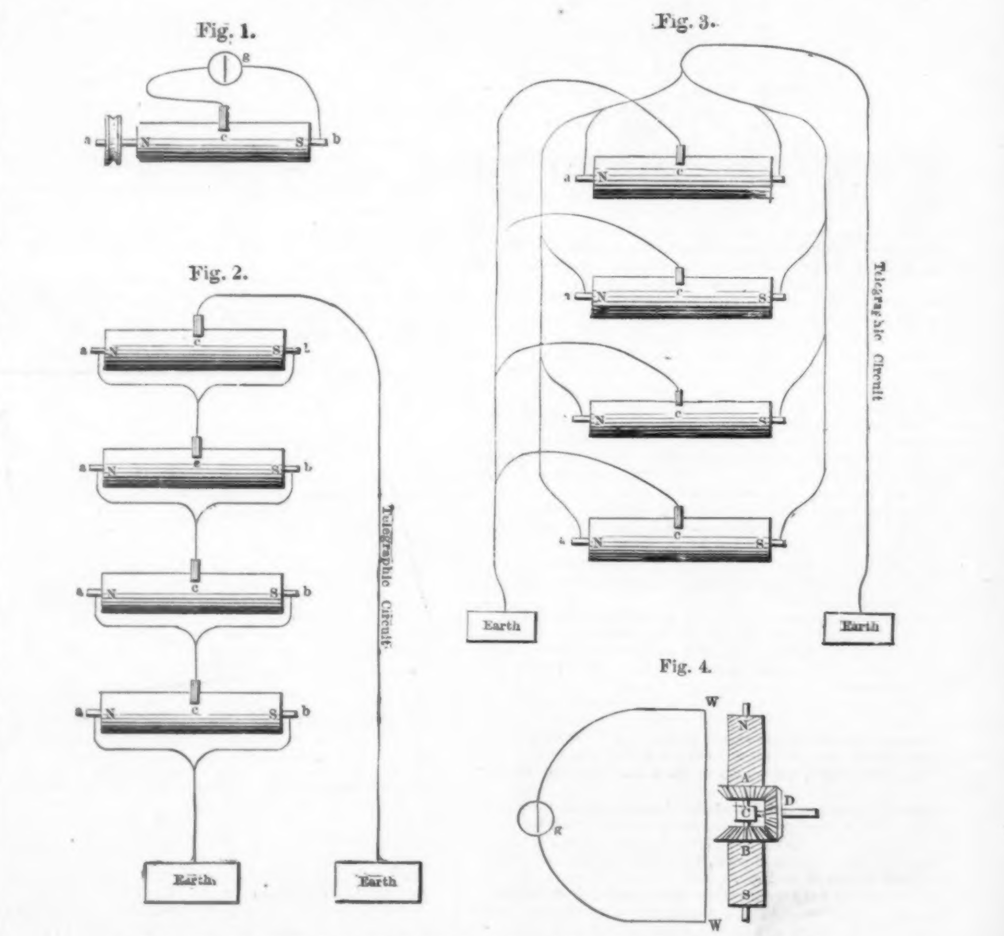
In illustration of my method of inducing a continuous current of electricity upon a telegraphic circuit, I shall show and describe one form of apparatus for producing the effect. I prefer to employ for this purpose a bar magnet, N S, Fig. 1, which can be caused to rotate upon its axis *a b* by means which it is unnecessary to describe. A metallic spring, *c*, rests against the center of the permanent magnet, N S. The instrument so constructed may be connected in circuit with a galvanometer, *g*, as in Fig. 1. When N S is caused to rotate upon its axis, *a b*, a continuous current of electricity traverses the circuit, *c* S *b g c*. The needle of the galvanometer, *g*, is deflected permanently so long as the rotation of N S is continued, and the deflection is reversed when the direction of the rotation is changed.

Figs. 1 and 3 illustrate the combination of a number of rotating magnets to form an electro-magnetic battery for use upon telegraphic lines. In Fig. 2 the battery is arranged for intensity, and in Fig. 3 for quantity. In Figs. 1, 2, and 3, N S N S, etc., represent magnets, which are caused to rotate upon their axes, *a b a b*, etc., the direction of the rotation being the same for all. Fig. 4 represents the manner in which a continuous current of electricity may be induced upon a closed circuit by the rotation of a permanent magnet in the neighborhood of the conducting wire, or *vice versa*, or by the revolution of the one around the other. This figure represents one way in which this part of my invention may be carried into effect, viz., by the rotation of the magnet in the neighborhood of the conducting wire.

N S is a permanent magnet, divided into two halves, N B and A S, which are magnetically united by an iron cog wheel, D, fitting into the corresponding cog wheels, A and B. C is a central support for the axles of the cog wheels, A, B, and D, and it is made of a non-conducting material. When the cog wheel, D, is made to rotate by means of suitable mechanism, rotation is also caused in the permanent magnet, N S, the poles N and S turning in opposite directions.

The rotation of the poles N and S occasions currents of electricity in the neighboring conductor W W′. Since N and S turn in opposite directions, the currents induced by their rotation in W W′ are in the same direction, and do not neutralize each other. The rotation of D thus occasions a continuous current of electricity upon the closed circuit W W′ *g* W, the needle of the galvanometer, *g*′, being deflected to the right or left, according to the direction of the rotation of D.

The permanent magnet, N S, Fig. 4, may be set in rotation in the interior of a hollow cylinder of copper, so as to obtain the full inductive action of the magnet all around; and the copper cylinders of a number of similar instruments may be united in series for quantity or intensity in an analogous manner to the arrangements shown in Figs. 2 and 3. The currents induced in the copper cylinders, and the currents induced in the rotating magnets themselves, may be thrown into the same circuit, so as to produce a maximum effect.



PROF. BELL'S IMPROVEMENT IN GENERATING ELECTRICAL CURRENTS.

[JOURNAL OF GAS LIGHTING.]

PIPES FOR GAS AND OTHER PURPOSES.

(Continued from SUPPLEMENT No. 70.)

MAIN-LAYING (*continued*).

WHEN laying mains, from the line of which the gas is not excluded, the bladder-valve, invented by Mr. George Lowe, is an indispensable appliance. This is represented in Fig. 52, and consists simply of a bladder, in the neck of which a piece of ⅜-inch brass tube, 6 or 8 inches long, threaded at one end, and having a stopcock at the other, is inserted; being firmly secured thereto with a piece of fine copper wire. A ½-inch hole is drilled in the completed portion of the main, at a distance of a few yards from the end. The bladder is inserted through this hole to within about two inches of the neck, and when in that position is inflated, filling up the diameter

FIG. 52

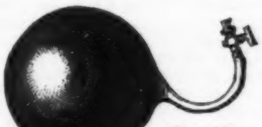


FIG. 53.

of the main, and the stopcock is then closed. By the use of this expedient, the passage of the gas is temporarily prevented, and the work of laying the mains can be proceeded with, not only without loss of gas, but without the inconvenience and danger of the escaping gas to the men employed. For pipes of greater diameter than six inches, the india-rubber gas-bag, Fig. 53, is used, and these are made of any required size. Accidents are occasionally caused by gas escaping past the valve, and mixing with the air in the newly laid length of main. The mixture, being explosive, has at times been accidentally ignited, with disastrous results. To obviate this, the valve should be removed daily, to a point as near to the end of the completed length of main as possible; and care should be taken to insure that the bladder or bag is sufficient in size, and that the inflation is perfect.

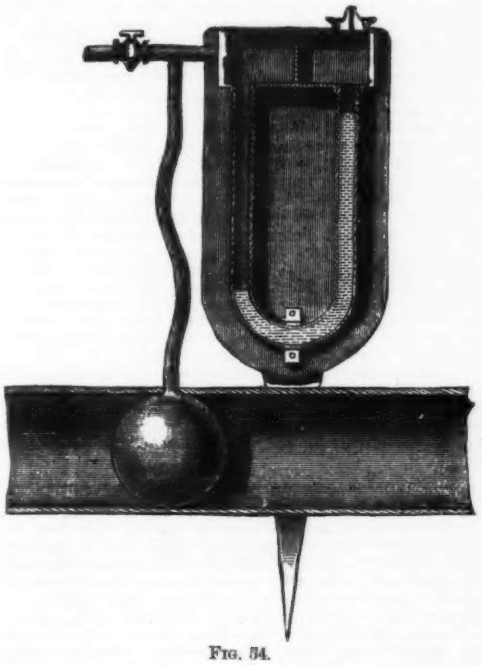


FIG. 54.

The use of an instrument resembling an ordinary pressure-gauge, Fig. 54, charged with quicksilver instead of water, is recommended by Mr. G. Goldsmith, of Leicester, as a safeguard against accidents of the kind mentioned. When the bag is distended, and the cock closed, the column of mercury will be raised to a height indicating the pressure, and an observation of the instrument will at once show whether the inflation is maintained. Any contraction or expansion of air from sudden changes of temperature is also compensated by the rise or fall of the mercury within the tubes. The boxes at the top prevent the escape of the mercury, if driven up by any sudden expansion or contraction. Attached to the instrument is a spike for fixing it in the ground.

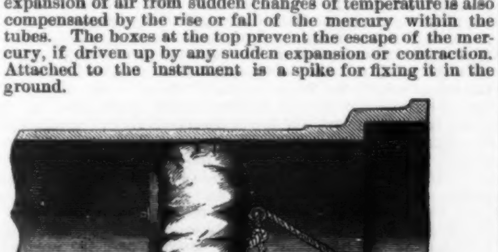


FIG. 55.

An ingenious contrivance, which answers the purpose of the bladder-valve, and dispenses with the drilling of the main, besides diminishing the risk of explosion, is that of the movable elastic plug. This consists of a bag made of strong canvas, varnished, and stuffed with some suitable material, the more elastic the better. An iron pin passes through the center of the bag, and is bolted to a wooden disk behind, all being made perfectly gas-tight. To the front end of the bolt or pin a loose iron ring is attached, and to this again a rope is fastened, Fig. 55. The canvas plug, being well greased round the sides, is inserted into the first pipe, and, before connecting the next, the rope is threaded through it by means of a rod. On the connection being completed, the plug is drawn forward two-thirds of the length of the pipe, and the process is repeated with each succeeding pipe until the whole are laid. The only objection to the movable plug is its liability to rapid wear, owing to the friction against the pipe sides.

The open end of the last pipe, as soon as it has been driven up, should be plugged, to prevent any possible escape of gas, or the accidental entrance of soil or stones from the cutting. A wooden plug is generally used. A very handy apparatus, devised by Mr. Edwin Addenbrooke, of South Hackney, may be recommended for that purpose. It is superior to the ordinary wood plug, inasmuch as it needs no driving, it adapts itself better to any irregularities in the pipe, and does not set fast. The apparatus, Fig. 56, consists of a disk of vulcanized india-rubber, A; a handle, B; and two plates, C and D. The handle has a cam action, and, when lowered into the position dotted, the rubber disk is compressed between the plates, closing the space, and adapting itself to any variations in the diameter of the pipe. In the diagram the apparatus is shown as being fixed in the socket end of the pipe; but it is, of course, equally applicable to the spigot end.

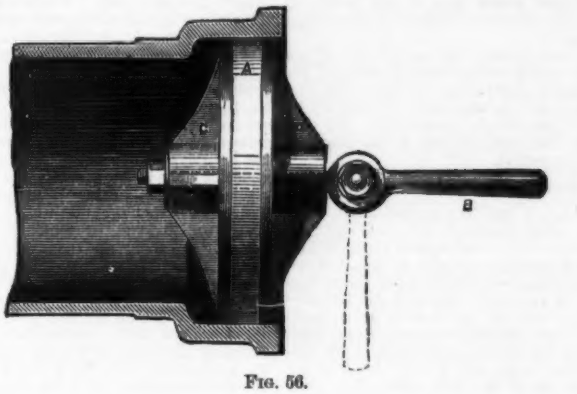


FIG. 56.

NATURAL GAS IN IRONMAKING.

I WENT out to Etna afterward to see how the rolling mills and the Isabella furnaces were getting along. One of the Isabellas is producing as much iron as ever—the extraordinary production of these two furnaces has made them famous; the other might be billed "closed for repairs," but I think that is not so. I think she is just filled up with coke and sealed—so as to keep her from cooling while she takes a rest. In the rolling mills they are running full time, night and day turns. They are making pipe, bars, and muck-bars—but by far the larger proportion is pipe work, both oil and boiler tubes. To judge from the manner in which work is being pushed along, I should say that there must be some heavy orders or a very active demand for lap-welded pipe of all descriptions about

By the way, I saw, for the first time, the gas heating of the furnaces, which has been adopted in these mills since I last visited them. It has proved as successful as it is singular. Here are mills with over 50 puddling and heating furnaces, besides boilers, etc., and there is not a ton of fuel—wood, coal, or anything of the sort—to be found on the premises. All the puddling, heating, and production of steam is done by igniting gas which comes from one of Dame Nature's gasometers in Butler county. In boring for oil, they struck an enormous gas well that came near blowing everything to pieces, till it was brought under control. This, of course, stopped the search for oil and ended in the present utilization of the gas. The gas flows from the well to Etna through a six-inch pipe, with a pressure at the well end of 260 pounds to the square inch, and the pressure at the rolling mills being 100 pounds to the square inch—the distance between the well and the works being 18 miles. But I can give those readers of the New York *Times*, who are not learned in the exact signification of so many pounds pressure to the square inch, a fair conception of how great this gas pressure is. When the pipes were being laid, some of the coal miners in the district were seized with the idea that the use of the gas was going to decrease the demand for coal, and thus work to their injury. They, therefore, planed down a lot of pump logs, and, as the laying of the pipes progressed, they would, from time to time, drive in one of these logs during the absence of the workmen. By leaving sufficient space for a certain, but insufficient, quantity of gas to pass, they hoped to fool the owners into the belief that the gas well was, after all, a failure. But these gentlemen were not so credulous as they thought they might be, and certain indications led them to have the pipes opened and examined in certain places. The result was the discovery of the plugs, and here comes in the curious and remarkable illustration of the pressure of the gas.

In order to make sure that all obstructions were removed, they put a solid India rubber ball, four inches in diameter, into the pipe at the well end, and then turned on the gas. The ball surpassed any previously recorded feat of this glory of Young America. It made the entire journey from the well to the mills, 18 miles, in just 16 minutes—a far higher rate of speed than I ever want to travel, especially when riding, as I did from Etna to Allegheny City, on the cow-catcher of an engine.

At night the surplus gas is burned, and produces an almost fabulous illumination of the surrounding country. I am told that you can see to read a newspaper by its light at a distance of a mile, and I know of residents at Etna who have been compelled to alter the location of their bed-chambers because they cannot sleep for the brilliant light whenever the surplus gas is ignited at the mills.

However, the great practical interest in the whole matter is in the success of the gas as a substitute for coal in puddling and heating furnaces. Of this I have been an eye witness. I peered into every puddling and heating furnace in both mills, and I venture to say that in no other mill in the country could iron have been more perfectly puddled or heated than it is by this gas in the Etna mills. Every furnace has its own connection with the distributing pipes, and the heat can be increased or lessened by the puddler or heater by a simple gas cock which is within his reach. Any one who owns a rolling mill will appreciate the value of being able to keep an idle furnace hot without cost of fuel or labor. It takes some time to heat up a cold furnace; and, moreover, it is the expansion and contraction inseparable from cooling off and heating up which plays such havoc with furnaces. *In all mills there are always a certain proportion under repair. But look at the enormous saving of cost in the production of iron. The pig iron has to be puddled and rolled into muck bars, the muck bars have to be heated and rolled into plates, and the plates have to be reheated, in order to be lap-welded into tubes. To do this would require, in an ordinary rolling mill, three and a half to four tons of coal to a ton of iron. Again, the enormous boiler power to run such large mills would also require a large average consumption of coal a day; and there must be added the cost for gas at night throughout the mills. Now, as a matter of fact, the whole cost for fuel in the Etna mills is comprised in the interest on the outlay of capital in sinking the well and laying the pipe, and the trifling repairs needed in the course of the year. Moreover, there are no charges to be debited to hauling coal and removing ashes, charges which are very heavy, too.

They use about 3,500 cubic feet of gas to a ton of iron; but what does it matter if they use six times that quantity, so long as they are obliged to burn off a surplus every day? Not the slightest diminution of the pressure has shown itself since the use of the gas as fuel began, and it is so great that if the full pressure were let into the pipes they would certainly burst. It is a most valuable, and yet comparatively costless, fuel with which to run a rolling mill, and, in these days of competition and close prices, it must give the owners of the Etna mills a margin of profit, which is easily estimated on every ton of finished iron they turn out, which must be beyond the reach of those who have to pay for coal for fuel.

True, coal is cheap enough in Pittsburgh, but here is a coal mine, as it were, that works itself and does its own transportation for nothing. I have written at length about this use of gas instead of coal for fuel, because it seems to me that a more general introduction of it may be possible in this district. If, as is more than probable, the gas has its origin from the same causes which produces petroleum, the oil fields of Pennsylvania may turn out to be also the revolutionary producers of sufficient fuel to run all the mills and furnaces in this part of the State. If so, it would form a very important feature in the future of the Pittsburgh iron trade.—*Pittsburgh Correspondence of New York Times.*

THE CHEMISTRY OF GAS MANUFACTURE.

By A. VERNON HARCOURT, Esq., F.R.S.,

One of the Metropolitan Gas Referees.

[A recent Lecture delivered at the Society of Arts, London.]

I PROPOSE this evening to give you, in the first place, a short account of the formation and chemical nature of coal, and afterwards to offer a general view of the subject, which I shall deal with more in detail in succeeding lectures, namely, the result of the application of heat to coal, especially in connection with the manufacture of coal gas.

Coal was formed from the air by a process, the beginning of which we are all familiar with through watching the growth of vegetation.

COMMON AIR.

The air consists, as you know, chiefly of oxygen and nitrogen, so that in 100 volumes there are about 78·4 volumes of nitrogen, and 20·6 volumes of oxygen; but it contains, also, small quantities of two other substances which for vegetation are much more important: namely, water and carbonic acid. Of water it contains ordinarily about 1 per cent., and of carbonic acid no more than ·04 per cent. Nevertheless, it is on the presence of these substances in the atmosphere that the growth of vegetation depends.

VEGETABLE ORIGIN OF COAL.

The plants which grew at the time when our main supplies of coal were formed differed greatly from those which exist on the earth at the present time; so much so that very few of them can now be referred by botanists to any existing genera. I owe to the kindness of Professor Tennant some diagrams which are now upon the walls, giving examples of a reconstruction of those plants. The remnants or impress of them are chiefly found, not on the coal, but in the shale, which underlies the coal, and which has preserved the record more perfectly than the more alterable, softer matter of the coal itself.

Although the actual genera are different from those which now exist, yet we may compare these plants with various existing genera. For example, this *Lepidodendron*, of which a portion is drawn here, appears to be a plant of the same kind as the small club moss with which we are familiar, but on a gigantic scale.

Again, there are representatives of the tree ferns and of the conifers, of which I have here some drawings. Then there is what seems to have been a large tree, which is called *Sigillaria*, because of the marks, as if impressed by a seal, existing on its stem; and what was formerly supposed to be a separate plant, but has now been proved to be only the

root on which this trunk grew. These roots or stools have been preserved more abundantly than the trunks, so that often where the trunk seems to have entirely disappeared, the roots remain, and as they were supposed to be different, they received the distinct name of *Sigmaria*.

Then, again, another variety of plant, which seems to have abounded in the coal measures, corresponds to the *Mares Tails*, which now grow in marshy places or equiseta. It is, however, uncertain whether the predominance of these varieties in the fossils of the coal measures depends on their greater abundance amongst the vegetation of that period, or rather upon the fact that they have better resisted the influences producing change to which this deposited vegetation has been subjected. Some interesting experiments were made several years ago by Professor Lindley on the powers which different plants possess of resisting decomposition, and he found that out of 177 kinds of plants which he left for two or three years under water, there were only 56 which had not wholly disappeared, and among these were the representatives of those varieties which are found in abundance in the coal measures, rendering it thus probable that the preservation of the forms of these plants may be due rather to their being able to resist the protracted action of water than to their greater abundance.

What may have been the nature and appearance of the forests or jungles which overspread a large portion of the earth's surface for countless generations of vegetable life, must remain but dimly known. In coal itself the very traces of organic structure are almost wholly obliterated. All that we can say confidently is, that coal consists of the mineralized vegetation of a former period.

HOW COAL WAS FORMED.

As to the way in which it has been accumulated, there were amongst geologists, some years ago, two rival theories. One view is that coal consists of the remnants of plants falling where they had stood, and that by a process of gradual decay, such as is now converting the heather of our moors into peat, these great masses of vegetable matter were accumulated and converted into a more or less homogeneous mass. The interstratification of these deposits with sandstone, limestone, and shale is supposed to have come to pass in the following manner: After these plants had grown and died for many generations, the portion of the earth where they grew was flooded, the vegetation was destroyed, and, during the time that it was submerged, mineral matters were deposited where the plants had grown. This submergence, also, we must suppose to have continued for a very long time; then the sea, or more often, it would seem, the fresh water, retiring, plants were again sown, and vegetation again throve for a long period; and thus the cycle of change repeated itself. Probably this is the true account of the formation, at any rate of the greater part, of the coal that we have. By this alternating deposition of vegetable and mineral matters, we have the state of things which an examination of the earth's crust reveals, and which is well illustrated by the section of the coal measures of the Forest of Dean, which Mr. Warrington Smith has lent me. Represented by this gray band is the new clay, which seems to have been the soil in which the plants of the coal measures grew. Then there is an accumulation of coal, the vegetable matter stored up; afterwards there was a period of inundation and of deposition of mineral matter, which went on accumulating for a long time. The thickness of these strata represents in some sort the length of the periods of time which intervened between each change. The breadth of the black line represents, relatively to the rate of deposition of the organic matter, the length of time during which the forest flourished. Then followed the deposit over it of sand, now compacted to sandstone, for a length of time, through a long alternation of periods here recorded in strata, and so on. No doubt the tax on the imagination of receiving a view of this kind is very great, especially if we figure to ourselves how long a period is required for the storage of the amount of vegetable matter which a single coal seam represents. The greater part, no doubt, of the carbon of these plants passed away into the air and disappeared, as the plants disappeared in Professor Lindley's experiments. Then we have to suppose these changes happening far inland, and simultaneously, over a great portion of the earth's surface.

The other hypothesis to which I referred is, that these deposits have been formed chiefly from vegetable matters carried down by rivers. There are examples of such accumulations at the mouth of the Mississippi and other large rivers, which best illustrate this hypothesis where there are great floods, and quantities of vegetable matter borne down and deposited in the delta of the rivers. What seems likely is, that both these causes have been in operation. But the extent and continuity and even thickness of the seams of coal, and the fact that trees are found standing upright with their roots still bedded in the under clay, make it probable that the former hypothesis truly represents the principal mode in which coal has been accumulated. But wherever the storage of vegetable matter and the deposition of great masses of other materials upon it, so that it has become deeply buried in the earth's crust, and subjected to a high temperature and great pressure—wherever this has happened, there has occurred the process by which coal is formed.

GREATEST DEPTH FOR COAL.

Then, besides the deposition of the vegetable matter, we have also to account for the change which it has undergone. The two principal causes which have concurred in producing this change are pressure and a high temperature. We know that now, as we descend through the earth's crust, the temperature rises at the rate of about 1° Fah. for every 60 feet that we descend. It is to be remembered, also, that of the coal which we can now reach, or which comes within the 4,000 feet of depth fixed by the Royal Commission as the greatest depth from which we should ever be likely to succeed in winning coal, much, at any rate, has been at another time at a greater depth beneath the earth's surface than we now find it, and that afterwards, by disturbances in the crust of the earth, it has been carried up to its present level.

Bischof has gone into the question of the nature of the changes by which woody fiber may have been converted into coal, and pointed out that there are various chemical changes by which this may have been effected. The abstraction of water, carbonic acid, and carburetted hydrogen, or of any two of these, produces an effect which may generally be described as a removal of a portion of the oxygen and hydrogen from the woody fiber—the carbon remaining behind in larger proportion. That, at any rate, is the nature of the principal difference between wood and coal, that oxygen and hydrogen exist in larger proportion in wood, and that the change by which coal has been produced has consisted in one way or the other in their more or less complete abstraction.

Another change, and one, perhaps, harder to understand, has gone on at the same time. Not only does coal differ from wood in the proportion of its organic constituents, but it differs from it in a remarkable way in its mineral constituents. The ash of coal is a very different thing from the ash of wood. Moreover, the ash of coal is almost the same as the ash of shale, and we must therefore suppose further that the coal, or the material of the coal, has been exposed to the action of water carrying mineral matters, either in solution or in suspension, for a sufficient length of time for its own mineral ingredients to be washed out, and those which were borne in solution or suspension by the water to have been substituted for them.

There on the wall is a diagram showing the position of the coal measures in a series of strata down from the surface of the earth, which may serve to illustrate the great depth where all these strata are superimposed of the formation in which the coal lies.

CHANGES IN COAL BY HEAT.

I pass next to the changes which are produced in coal by the application of heat. Such changes occurred independently of man's agency, and at a period long before man appeared upon the earth. We know that in several parts of the earth it has been observed that inflammable gases issue from the ground. At Chat-Moss, in Lancashire, it was observed long ago—that by simply making a hole in the ground, placing a pipe in the hole, and applying a light, a flame could be maintained for a long time; and actually such gas has been applied to the lighting of buildings. Then, again, not only does nature make gas, but in making gas nature makes coke. Anthracite is natural coke—it is coal which has been exposed to a high temperature, and thus has undergone the same changes which we produce in coal by exposing it to artificial heat. When coal is heated, the change it undergoes depends upon the temperature to which it is heated, or the rate at which it is heated. Probably the meaning of this is, not that coal, speaking of it as one substance, undergoes different changes, according as it is heated quickly or slowly, but rather—which, I think, is the true explanation of the matter—that, when it is heated quickly, the products which are first produced by heating it are exposed to the high temperature before they can escape. Probably the effect of heating coal quickly to a high temperature might be perfectly imitated by subjecting the products of its decomposition at a low temperature subsequently to a high temperature. This may be difficult to effect on a manufacturing scale, or may have no economical advantage. I believe something of the kind has been tried, but the true account of the matter is probably this—not that the same substances undergo chemical changes different according as they are exposed at once to a bright red heat, or gradually and gently heated; but that, when coal is treated in the way in which it is treated in a gas retort, and is suddenly exposed to this strong heat, the substances which would be simply distilled from it, if it were first heated gently, come into contact with strongly heated surfaces, and thus undergo a further change. The difference in the result is, that coal which is gradually heated gives off a much larger proportion of liquid and a much smaller proportion of gaseous products than coal which is suddenly heated strongly.

OIL FROM COAL.

When the process of heating coal for economical purposes was first introduced, I believe the object in view was not the production of gas, but of the liquid and solid products. In 1781, Lord Dundonald took out a patent for the distillation of coal, his object being to produce *brown oil*, as it was called, naphtha, ammonia, and coke; but the gas was let go. Works for this purpose were in operation for nearly 50 years at Muirkirk, in Ayrshire. A curious circumstance in connection with these works is, that among the coal which was thus treated was found some cannel, which was thought to be unsuitable and thrown away.

GAS FROM COAL.

I have here a miniature gasworks, lent by my friend Mr. Fison, which is now in action, and shows every step in the manufacture of coal gas, the heating of coal in the retorts, condensation of tar, ammoniacal liquor, washing, purifying, storage, and distribution. There are also on the walls a set of diagrams, lent me by Dr. Frankland, illustrating the same operation.

The solid residue, when coal has been heated in the retort, is the well-known substance called coke. The same substance, or very nearly the same substance, is also produced in coking ovens for use in locomotives, and for other purposes. It contains some three-fourths of the total weight of the coal which is distilled, and when the coal employed is a caking coal—that is, a coal which, when it is heated, is sufficiently bituminous to partially fuse, and so aggregate itself together—the coke remains behind in a solid piece, such as I have here. In many respects coke is superior to coal as a fuel. It has over coal the same advantage, for many purposes, that anthracite or steam coal has over other coal. You know that for use on board ship, and wherever a clean fire is required, the steam coal, or smokeless coal, is greatly preferred to ordinary bituminous coal. We do not commonly use coke for fires in our sitting-rooms; but I believe that this depends upon the form of grates which we are accustomed to use. A better form of grate has recently been advocated, under the name of Slow Combustion Grates, in which the air is not admitted to the fire from below, but only in the front. The effect of admitting air through an open grating beneath the fire is to cause the coal to burn quickly away. If air enters from the front, combustion takes place, and each coal glows on the side towards the room. The grate should have a high and wide front, but be shallow from front to back, and have flat bars edgewise, or rather far apart. The open space above the top bar should be no more than sufficient for putting on coals. In a grate of this kind, as I can testify from my own experience, coke can be burnt with the help of a little coal, just as well as coal, and with a better heating effect. I cannot but think that the consequence of the reform in our grates, which I hope to see, will be that this fuel will be largely substituted in domestic use for coal, to the advantage both of the householder and of the gas manufacturer. At times like the present, when the price of coal is lower than it has been, and the winter is mild, the quantity of coke which accumulates is very large, and the value of it to the maker is often very much below its real value. The reason we now use the bright or blazing coal in our fires is, that the air being admitted through the bars below, the chief part of the combustion goes on there, radiating heat only upon the hearthstone and the upper part of the fire, which is what we look upon, would be dull, unless we used a coal yielding a great deal of gas, in order that we may have a blaze at the upper surface, and see something bright.

GASES AND VAPORS.

The gases which pass out from the retort consist partly of what are termed permanent gases, and partly of what are distinguished as vapors; that is, of gases which, under other circumstances, would not be gases but liquids.

This distinction between gases and vapors is more misleading than it is serviceable. When we speak of a substance which is perfectly gaseous as a vapor, we recall by that word a circumstance which is generally quite irrelevant—namely, that under other conditions, if the temperature and pressure were different, this substance would be a liquid. Most probably the same is true of every gas; we know it to be true of all gases except six. It is as though we restricted the word "liquid" to permanent liquids like alcohol, and had another word for liquids which could be frozen. However, at the ordinary temperature, a great deal that is gaseous at the high temperature of the gas retort becomes liquid, and so is collected separately.

SUBSTANCES DERIVED FROM COAL.

I have on the wall two long tables, giving the names and chemical formulæ of the great variety of substances which have been found among the products of the destructive distillation of coal. You will see that in one table all the substances, whose names and formulæ are given, consist of combinations of two only of the elements of coal—hydrogen heading the list, and all the other substances being combinations of it with carbon. Those which stand first on the list—hydrogen and marsh gas—are both permanent gases, which have never been liquefied. The others are substances which exist in the gas, and which are also partially condensed with the tar. They are grouped here according to their chemical classification, not according to their chemical volatility. Those which come lower down are liquids. Paraffin is the name generally given to a solid substance that is obtained from coal, and it is given also by chemists to both liquid and gaseous substances which have the same general formula, $C_n H_{2n+2}$. Acetylene, again, is a gaseous hydrocarbon; then comes some of the principal of the liquid bodies that are produced. Naphthalene is sometimes gaseous and sometimes, unfortunately, solid. It is liable to be deposited, and to obstruct gas pipes at a distance from the works. Anthracene—a substance of which I shall have more to say presently—is also a solid substance. Then there are others into which oxygen, nitrogen, and sulphur enter, in combination with carbon, or hydrogen, or both.

VARIETIES OF COAL.

This other table gives the results of a number of analyses of the different kinds of coal. The varieties of coal range, shading one into the other, from that containing the largest proportion of carbon—namely, anthracite—to highly bituminous coals, passing on into cannel coal, and into a substance about which there has been a dispute whether it is coal or not. This is Boghead cannel. This still richer substance, of which Mr. Evans has kindly sent me a specimen—Boghead shale, as it has been called, from its resemblance to Boghead cannel—comes from Australia. You will see, from the specimens I have here, how extremely these substances differ in appearance from each other: indeed, different samples of cannel coal differ very much from one another, some being quite devoid of lustre, and some being brilliant like anthracite. The more bituminous coals yield a larger proportion of liquid products. Coals are called bituminous, not because they contain bitumen—for this substance cannot be extracted from them—but because they yield it when they are heated. As to the actual substances existing in coal, very little is known, because the actual constituents of coal are extremely insoluble, and chemists have not succeeded, by the application of solvents, in extracting directly (by processes which will produce no change in the coal) substances which they can isolate and examine. Thus it happens that our knowledge is almost entirely of the substances producible from coal by heat, and not of the substances—equally definite, no doubt—which already exist in it.

I shall have to speak in a subsequent lecture of the substances which enter into ammoniacal liquor, as it is called, but will pass now to the other of the two liquid products of the destructive distillation—namely, tar; and consider the nature of some of the products which have been obtained from it.

COAL TAR AND ITS REMARKABLE PRODUCTS.

Tar is a mixture, in varying proportions, of a great number of different substances. When it is heated it is divided into more and less volatile parts. There distils from it first some water—indeed, a principal difficulty with a tar distiller is to get rid of the water with which the tar is mechanically mixed. After that there comes over a substance which the tar distiller calls "liquid naphtha," which is subjected to a subsequent distillation. Next there comes over a substance of a higher boiling point, of a consistency which is almost solid—a buttery substance which is called "creosote;" and, lastly, there comes over a substance which is at first more fluid, but afterwards nearly solidifies, called "anthracene oil," because anthracene is obtained from it. That which first distils over has nothing characteristic in its appearance, being a limpid, colorless liquid. In these bottles are the products of subsequent distillation.

NAPHTHA.

The crude naphtha is first acted upon by soda. It is brought into contact with something like one-third of its volume of a strong solution of soda. It contains, besides benzol and other similar hydrocarbons, a quantity of another important substance—namely, carbolic acid. This unites with the soda, and the two together form a heavy liquor, on the top of which the lighter naphtha floats. The liquor is drawn off and mixed with sulphuric acid; it separates, as it cools, into two layers, the lower one consisting of a solution of sulphate of soda, and the upper one of the crude carbolic acid. The tar distiller carries the operation no further than to run away the sulphate of soda, of which he makes no further use, and to draw off the carbolic acid. The naphtha is next acted on with sulphuric acid, which combines with the organic bases substances containing nitrogen, as well as carbon and hydrogen, and the purified naphtha, now containing only hydrocarbons, is distilled. In this first distillation the greater part is collected together, and a small quantity remains behind, which is rejected or mixed again with the crude naphtha. It is then what chemists call "fractionally distilled"—that is to say, distilled in a gradual continuous operation; while the runnings of the still are collected separately. The receivers employed are carboys; the order in which they are filled is noted; and subsequently an examination of their contents is made, and the liquid products classified accordingly. The examination consists in determining the boiling point of the liquid. According as the manufacturer wishes to have a hydrocarbon of a higher or lower boiling point—which depends on the demand in the market—he mixes with the first portions dis-

tilled a larger or smaller proportion of the subsequent distillate, so as to have either a larger quantity of somewhat higher boiling point, or a smaller quantity of lower boiler point. These two are called respectively 90 per cent. benzol and 50 per cent. benzol—meaning a liquid which is judged, from its boiling point, to contain 90 or 50 per cent. of pure benzol.

BENZOL.

Benzol is a hydrocarbon, of which the formula is $C_6 H_6$, and it is associated with other substances—namely, toluol, xylol, cumol, and cymol—substances which are homologous with benzol. These substances form a series proceeding in arithmetical progression by a difference of one atom of the carbon and two atoms of hydrogen, the first having the formula $C_6 H_6$, the next $C_7 H_8$, the next $C_8 H_{10}$, and so on. They are all mixed together in the naphtha, and they are, to some extent, separated from one another, in the fractional distillation, by the tar distiller. The purest benzol which is ever collected by the manufacturer contains some admixture of the other substances; but I have been lent, by Mr. John Williams, some samples of these different substances in a pure condition. Here are benzol, toluol, and xylol. Their appearance is absolutely similar; all are mobile, colorless liquids; but we should find if we were to place them in a flask with a thermometer, and heat them until they distilled freely, and observed the temperature, it would be in the three cases, 84°, 114°, 126°.

The actual distillates collected at the tar distillery consist of mixtures of these substances boiling at temperatures which differ according as the hydrocarbons of lower or higher boiling point predominate. I have here some samples of the commercial products, which I obtained to-day, through the kindness of Messrs. Blott from their distillery.

The sample next in volatility to benzol is called "solvent naphtha," the purpose for which it is employed being to dissolve india-rubber.

After a time, as the temperature rises, the liquid which comes over is found to be of too high a specific gravity, and unfitted for this purpose, it is called "burning naphtha," and is sold for burning in such lamps as are used sometimes to light stalls in the open air.

CREOSOTE.

The second product of the original distillation—namely, "creosote"—is a pasty mass, which, on standing, divides itself, to some extent, into an oil and a solid, the solid being naphthalene. The chief use of this substance is for pickling timber; especially, I believe, railway sleepers. The pieces of wood are placed in cylinders from which air is exhausted, and then this substance is let in upon them, and forced into their pores by the atmospheric pressure. The wood is thus rendered more capable of resisting exposure to moisture and the attacks of insects than it otherwise would be.

Some portion of the oil which drains from the semi-solid mass is also used for making lamp-black. It burns with a very luminous, fuliginous flame, and the soot which is formed is collected and called lamp-black.

ANTHRACENE OIL.

The third product is "anthracene oil." This divides itself into a liquid and a solid. It is poured upon frames, carrying a filtering material, and the oil runs through, while the solid remains upon the filter, and is afterwards transferred to bags, where it is allowed to drain, and is then more completely dried and freed from the adhering oil by pressure.

Here are the three substances: the anthracene oil, which has a solid layer now settling, the "green oil"—so called from its color—which is used for making grease, and thirdly anthracene.

I have here a pure specimen of the naphthalene, which is the solid substance accompanying the creosote; and also one of anthracene and of carbolic acid.

PITCH COKE.

Besides the three distillates, the tar which is distilled leaves this solid substance called "pitch:" which, also, is applied to various purposes, the principal, I believe, now being that of making artificial fuel. It is mixed with breeze, and the pitch serves as a sort of cement to compact together other combustible substances, the whole forming a serviceable fuel. It is also used for making artificial asphalt, and in preparing a kind of felt.

It has also been supposed that by further distillation of this substance a further quantity of the valuable anthracene might be obtained; but I understand that although the substance yielded by the destructive distillation of pitch greatly resembles anthracene, there is found to be some difference between them, which renders it not serviceable as anthracene is. The solid residue of the distillation of pitch is that which I have here—pitch coke—a very pure form of carbon, being almost free from ash, since it is formed by the destructive distillation of a substance which itself has been gaseous.

I have only a few words to add about the substances which are formed from these; but it is the less necessary to go at length into that part of the subject, though it is very interesting and important, because some seven or eight years ago it formed the subject of a course of lectures given here by Mr. Perkin, who is the principal among those who have developed this important and beautiful industry.

HOW ANILINE IS PRODUCED.

One substance directly produced by the destructive distillation of coal is "aniline;" but this is not produced in large quantity; and is not easily isolated. It was found, first, that from benzol, a substance of some use in perfumery, it may be obtained by the action of nitric acid, the product being called nitro-benzol; and it was also found that by the reduction of this substance—that is to say, the replacement of its oxygen by hydrogen—it was converted into aniline. This reduction was first effected by the action of sulphide of ammonium; but it was afterwards discovered that it was effected equally well, and more economically, by the action of acetic acid and iron. So that, though coal and coal tar are the great sources of aniline, it is not obtained directly from them, although it exists there, but indirectly from the benzol, the benzol being first transformed by the action of a mixture of sulphuric and nitric acid into nitro-benzol, and then the nitro-benzol being further transformed by the action of reducing agents into aniline.

MAUVE.

The first great discovery was that, by the action of oxidizing substances upon aniline, it was transformed into a black powder which was serviceable as a dye. By the action of sulphuric acid and bichromate of potash, aniline was transformed into a substance to which the name of "mauve" was given. Subsequently, in the hands of Mr. Perkin and others, this production of coloring matters from aniline received a very great development, and the consequence was the production of a number of beautiful pigments which are familiar to all of us, and of which I have here some specimens which Mr. Perkin has given me. There is, I think, no more striking or more beautiful result of the application of chemistry than that it should be possible, from such a substance as coal tar, to obtain substances, at the very opposite end of the scale of mineral being, like these beautiful colored products.

ANTHRACENE.

There is one other point only which I would name. From the anthracene oil anthracene is obtained; and from anthracene, by a series of processes which it would take me too far to go into, a substance which has long been used and known —viz., "alizarin." The investigation of madder, some 40 years ago, showed that the coloring matter consisted principally of alizarin and purpurin, of which alizarin was the more important. Then followed the great discovery that by a succession of operations upon anthracene, it can be transformed into the same substance which is the coloring matter of the madder root; so that now actually the use of madder as a dye stuff is, I believe, almost disappearing: its place being taken by what can be produced to greater advantage economically—namely, the very same material produced from coal tar.

This is really the crowning triumph—at least, it is difficult to suppose it can ever be surpassed—viz., the application of chemistry to the arts; and with this I conclude the present lecture.

[COAL TRADE JOURNAL.]

COAL MINING AT STEUBENVILLE, OHIO.

By ANDREW ROY.

THE plan of laying out the workings which prevails at the Steubenville mines is modeled after the practice followed in the collieries in the north of England. The pillars left in the English mines are larger and stronger than those in Steubenville, because the pits are so much deeper in the old country, some of these reaching 1,800 to 2,500 feet of perpendicular depth. In Steubenville the rooms are eighteen feet wide, the walls or cross-cuts twelve feet wide, the pillars twenty-four feet in thickness and seventy-two feet in length. The walls and rooms cross each other like latitude and longitude lines; the walls being driven on the butts, and the rooms on the face of the coal. The main entries are ten feet wide. The miners get seventy-five cents per yard, besides the tonnage price for driving entry, but nothing is allowed for wall driving.

The mine cars hold twelve and one-half bushels, and are pushed out from the room faces to the stations on the hauling roads by putters or pushers. In Boreland's shaft, Shetland ponies are used instead of putters. These ponies are only three feet two inches to three feet six inches high. This mine has seven of these hardy and useful animals under ground. In the galleries and hauling roads, a foot or more of the fireclay floor is taken up to make height for the hauling mules. These roads are made five feet two inches high above the rail, and the track is laid with "T" iron. The coal hewers dig and load the coal, the deputies laying track and setting props in the rooms. Every digger works by candle light, instead of the ordinary miner's lamp. The candles are made very small, there being twenty to the pound; they are fastened to the pillar side with a piece of soft clay. Three to three and a half of these candles are consumed per day by each miner. These candles give less light than the miner's lamp, but they make no smoke, and miners who are in the habit of using them prefer them to the lamp. The deputies and drivers, however, use lamps.

In mining the coal, powder is used to knock it down, each digger firing three shots per day on an average; two in the top and one in the bottom coal. The workmen fire at all hours of the day, but a few inches of powder suffices for a "shot," and not more than three pounds of powder per man per week is needed for blasting purposes. No blasting is done in the solid coal; a shot is undercut to the depth of four feet if the miner is a skillful workman, the undercutting being made ten feet from the coal floor.

The mine mules are kept day and night under ground; the stables being hewn out of the solid coal pillars at the bottom of the pit, and are dry, well aired, and comfortable. The mules are fed at four o'clock in the morning by the fire-viewers. Work commences at six o'clock, an hour is allowed at noon for dinner, and work ceases at five in the evening.

The miners are paid every two weeks in cash, and there are no store orders forced upon them, as is done in many other districts of the State. As the Bustard, the Grand, the Stoney Hollow, the Market Street, the Rolling Mill, the Emrick and Boreland shafts are all situated in Steubenville or its immediate vicinity, the miners live in towns, and a large number of them own the houses and lots in which they live, and have in many cases other property. Fully one half of them take daily newspapers; though, it must be confessed, that here, as well as everywhere else in this Union, not a few spend much of their hard earnings in the saloons in soul-debasing pleasures.

At four o'clock in the morning, the fire-viewers, consisting of the underground manager and two or three assistants, called deputies, go down the pit with safety lamps in hand, and, until they have traversed the mine and signalled back that all is safe, no person under any circumstances is allowed to descend. The fire-viewers, on receiving orders from their chief, start out in different directions and examine the numerous chambers with the safety lamp. If gas is met in any of the rooms, it is usually driven out by the viewer, who, leaving his safety lamp back in the pure atmosphere, takes off his coat and slashes among the gas till it is all driven out and diluted among the common air. Should the gas be so copious that it cannot be discharged, the place is marked, and all persons are forbidden to enter until the air is got up and made to play on the wall face. This condition of a working place is, however, seldom met, so admirable are the ventilating arrangements of these mines. Having made the round of the mine, the deputies meet the manager at one of the stations, previously agreed upon, and report; everything being satisfactory, all return to the bottom and the signal is given to the miners to descend.

The workings of the Stoney Hollow and Market Street mines are holed through on each other, the former shaft workings being in reality an extension of the northern workings of the latter mines, both mines belonging to the Steubenville Coal Mining Company. These pits are about two thousand feet apart, Stoney Hollow being nearly due north of Market Street. The horizon of the coal in the bottom of the Stoney Hollow pit is twenty-two feet higher than in the bottom of the Market Street pit, and this raise occurs in the last seven hundred feet in approaching Stoney Hollow.

There is a continual local waving up and down in the coal floor, though the waves do not interfere with the general dip of the strata; nor does the thin seam immediately above conform to the local dips and rises of the lower and thicker bed. These two seams are sometimes together, and sometimes six and ten feet apart within the area excavated by the Market Street and Stoney Hollow workings. No true line of divergence and convergence can be traced from one mine to the other, as the upper seam, in developing, passes into the roof and is lost sight of, being shown only where the roof has fallen down in the rooms. In the shaft of Stoney Hollow, these two coals are separated by three feet of slate; in the Market Street shaft they are six feet apart.

The Rolling Mill shaft has a pair of entries sixteen hundred feet in length, driven in an eastern direction from the bottom of the shaft. They passed directly under the Ohio river, and were stopped after passing one hundred feet into West Virginia. At this point they encountered a feeder of water, and the coal itself became so soft that it was deemed prudent to stop operations.

The entries dipped all the way from the bottom of the shaft till within four hundred feet of the West Virginia side of the river, the low place or basin being twenty-two feet lower than the bottom of the shaft. From this point until they were stopped there was a gradual raise in the entries.

On the West Virginia side of the river, where these subterraneous galleries end, there is a flat or bottom several hundred yards in width, where the river at some former period flowed, and as the present bed of the Ohio is at least one hundred and fifty feet higher than its ancient bed, the coal is doubtless eroded under this flat. It was fortunate for the bold mining adventurers that the ancient river bed was not immediately below the present bed, for, had this been so, the entries might have driven into it, notwithstanding the unusual care and caution exercised in passing under the river. The proprietors of the Rolling Mill shaft own five hundred acres of coal lands on the West Virginia side of the Ohio river.

Several years ago, a creep commenced in the workings of the Rolling Mill shaft. Fifty rooms in the Rolling Mill pit were involved in the creep; which then extended to Enericks, closing the main galleries of that mine for a width of four hundred feet, and overrunning the most valuable portion of the mine, being resisted only by the solid body of the coal at the room faces. The superincumbent strata, westward of these shafts, are fully five hundred feet thick, and are mainly composed of heavy beds of sandstone. The roof and floor of the mine came together by the pillars sinking into the floor, and new roads had to be cut out of the bottom at great labor and expense.

The mining properties of several of the coal companies border each other. By common consent a barrier pillar, forty feet in thickness, is left at the boundary line—twenty feet by each company. This is a wise precaution, and should be required by law at all mines in the State. Already considerable annoyance has been caused in consequence of one mining company working up to, or trespassing upon, the boundary of an adjoining company, and, eventually, serious accident from water or gas will result.

ORTHOCLASE, OR COMMON FELSPAR.

IT derives its name from the fact that the crystals have two principal directions of cleavage, which form a right angle with each other. Its hardness is inferior to that of quartz, nevertheless it is greater than that of ordinary spars, since it will make scratches on glass; hard steel will touch it, but with difficulty; its specific gravity is moderate. The crystals in the granite used for the construction of the bridges, etc., referred to above, are mostly orthoclase, and in these cases it will be seen that the crystals are imbedded in a paste. To a rock of this kind the term porphyry is given; if, however, the crystals of felspar are not so very distinct from the rest, but two or three different substances are so distinctly crystallized out, the term porphyritic granite is often applied. Beautiful varieties of this porphyry may be seen in different places; thus the public buildings of Penzance, in Cornwall, are built of a beautiful material of this kind, and reference may also be made to the granite from Shap Fell, in Cumberland, which in the last five or six years has found its way into London for ornamental purposes—columns, etc.; some of the elements of its beauty and utility being its hardness, its pink color, and this porphyritic structure. In the Alps, again, and in the neighborhood of Lago Maggiore, large blocks of granite are thrown from the mountain side on to the plain below by small charges of powder, and often on examining these it will be found that in cracks and cavities the felspar, along with quartz and mica, is beautifully crystallized, sometimes on a large scale. Other notable localities are the island of Elba, and the Mourne Mountains, in Ireland. In some instances the crystals of felspar are more translucent, looking more like glass; and being found in the Alps, in the vicinity of St. Gothard, they have been named "Adularia felspar," from a mountain there known as Adula. In the Island of Ceylon this variety of clear felspar has a tendency to appear rounded, and is found when cut to present a peculiar lustre, something like mother-of-pearl, hence it is usually termed "moonstone," and is much valued for ornamental purposes. Felspar is found in other cases with a yellowish, brownish, or reddish tint, and a green variety, from Siberia, has received the special name of "Amazon stone." Some beautiful examples of this latter variety have recently been found near the line of the Pacific Railway, and the Museum owes some fine specimens to the liberality of a lady. If we look at the composition of this orthoclase, we find that it is a silicate of alumina, with a silicate of potash, one specimen giving on analysis about 65 per cent. of silica, 18 per cent. of alumina, and 14 per cent. of potash, with very small quantities of lime and soda. The presence of potash in this substance is of great interest to the agriculturist, since the soils produced by the decomposition of rocks containing orthoclase will be suited to certain plants, to the life of which potash is so important. There are cases where this kind of felspar constitutes an entire rock, as at St. Stephen's, Cornwall. Certain building stones contain another variety of orthoclase, known as "glassy felspar," and notable amongst these is the trachyte of the Rhine district, while the magnificent cathedral at Bologne may be pointed out as an example of its use.

To another specimen of felspar the name "albite" is given, in consequence of its whiteness. Crystals of this felspar occur generally on a smaller scale than orthoclase, and are almost universally twin crystals, often appearing as if the crystal had been cut in two and one half turned on the other, so as to form a re-entering angle. It is a silicate of alumina and soda, and thus differs from orthoclase in having the potash of the latter replaced by soda. The question arises whether the potash and soda from these two substances—both valuable materials—could not be economi-

cally obtained; and in certain cases this can be done. In certain porphyritic rocks these two species of felspar are found together. "Oligoclase" is another species, containing little potash, but much soda, and some lime; it derives its name from the fact that its cleavage does not produce right angles. The term "labradorite" is applied to still another species of felspar, which occurs abundantly in Labrador. Like the last two felspars, the crystals of labradorite belong to the anorthic system, or the system in which none of the three axes are at right angles. The crystals of labradorite present usually a grayish appearance, but when the light is seen reflected from them in a particular direction they show the most gorgeous colors, and at the same time a very delicate striation, which structure is intimately connected with the production of color. This labradorite is composed of a silicate of alumina, coupled with a silicate of lime, and a fair proportion of soda. Consequently, when the rocks of which labradorite is a chief constituent decompose, they give rise to soils rich in lime. If we look to the localities in which labradorite occurs, we shall find it is a very important material; it occurs abundantly in the basalt, augitic porphyries, and modern lavas of the Sandwich Islands, Iceland, Vesuvius, Etna, etc. And when these decompose, so far as to form soils, they often produce very rich soils indeed; and it is interesting to note that from soils thus formed in the vicinity of Vesuvius and Etna some of the most famous grapes and wines of the world are produced. "Anorthite" is a fifth species of felspar, and is so called from the fact that in the form of its crystals there is no right angle; it consists of a silicate of alumina and of lime, and occurs on a very small scale only. There is a question as to whether these are all distinct species of minerals, or whether some may not be merely mixtures of two or more species.

In the lavas of Mount Etna labradorite is very frequent, some of the more modern ones being composed almost entirely of labradorite and augite. And even in our own districts this mineral plays a very important part. The "whin sills" of the North of England, the great masses of dark igneous rock in the Dudley and Newcastle coal fields, and in the great tract which reaches from the Castle Hill at Edinburgh to the Castle of Dumbarton, these rocks, which are variously called plutonic, trappean, or volcanic, contain this felspar as a most important constituent.

And connected with the series of felspars there is the enormous economical importance of the substances produced from some of them. In certain districts of Devon and Cornwall orthoclase occurs in a very soft and powdery condition. And about a 100 years ago Mr. Cookworthy, an intelligent gentleman of Plymouth, and a Saxon chemist independendently came to the conclusion that this kind of powder was the same material as the kaolin from which the Chinese manufacture their very best china. In England a pottery was established at Plymouth, and then Wedgwood and others took it up, and it has since become one of our staple branches of manufacture. From the discovery by the chemist alluded to sprung the famous Dresden manufacture.

In the year 1800 the quantity of this so-called Cornish clay exported from Cornwall was about 2,000 tons, in 1839 it had reached 7,600 tons, while last year the quantity was 108,000 tons. Another substance, known as China stone, was exported to the amount of 38,000 tons. In Devonshire, on the east side of Dartmoor, is a deposit formed by Nature of a clay very commonly called pipeclay, of which 29,000 tons were produced; while if we pass still further eastward we find that a variety of clay, known as potters' clay, was exported from Poole to the amount of 65,000 tons, while 60,000 tons of the same material were exported from Devonshire. In fact, as a whole, 2,000,000 tons of these different varieties of clay are produced. And there is no doubt that, as in the case of kaolin, they are all produced from the decomposition of felspar.—*Prof. Smyth, in Mining Journal.*

OHIO MINERALS.

Perry, Hocking, and Athens counties, in Ohio, are now attracting a great deal of attention as "iron manufacturing sites;" containing as they do, beds of coal, iron ore, and limestone in the same hills, and often level free, they are destined to become great mineral regions in the near future—the "black country" of Ohio, if not of the United States. The great vein seam of coal measuring nine, ten, eleven and twelve feet in thickness, first began to attract the attention of capitalists in 1869.

THE BABCOCK & WILCOX SECTIONAL BOILER.

Among the steam boilers submitted to test at the Centennial Exhibition, the sectional boiler made by the above concern will well repay investigation of its characteristics, and discussion of its performance, as indicated by these tests.

The mechanical world has suffered so severely in time past from disastrous boiler explosions, that immunity from destructive rupture has come to be a consideration of paramount importance in such an instrument; and has resulted in the production of a large number of boilers of the type known as sectional, in which the especial feature tending to increased security, is that of subdividing a single large volume, as in the ordinary or non-sectional type, into a number of lesser volumes intercommunicating in such a way as to constitute, practically, a large number of small boilers joined together. In this way, the strength is enormously increased, and the destructive effect of the rupture of one of these small boilers, or sections, will be somewhere in the inverse proportion of their number; and as the number of these sections, or units, may be indefinitely increased, and their individual volume be made indefinitely small, they may be constructed to be absolutely safe under any contingency which can happen to a steam generator. The more modern and increasing demand for high pressures as indispensable to the economic use of steam, and as shown particularly in the increasing popularity of the compound engine, may be met more securely with this type of boiler; as we cannot doubt but danger increases in some proportion with the pressure carried in the forms of boilers having outer shells inclosing a single large volume.

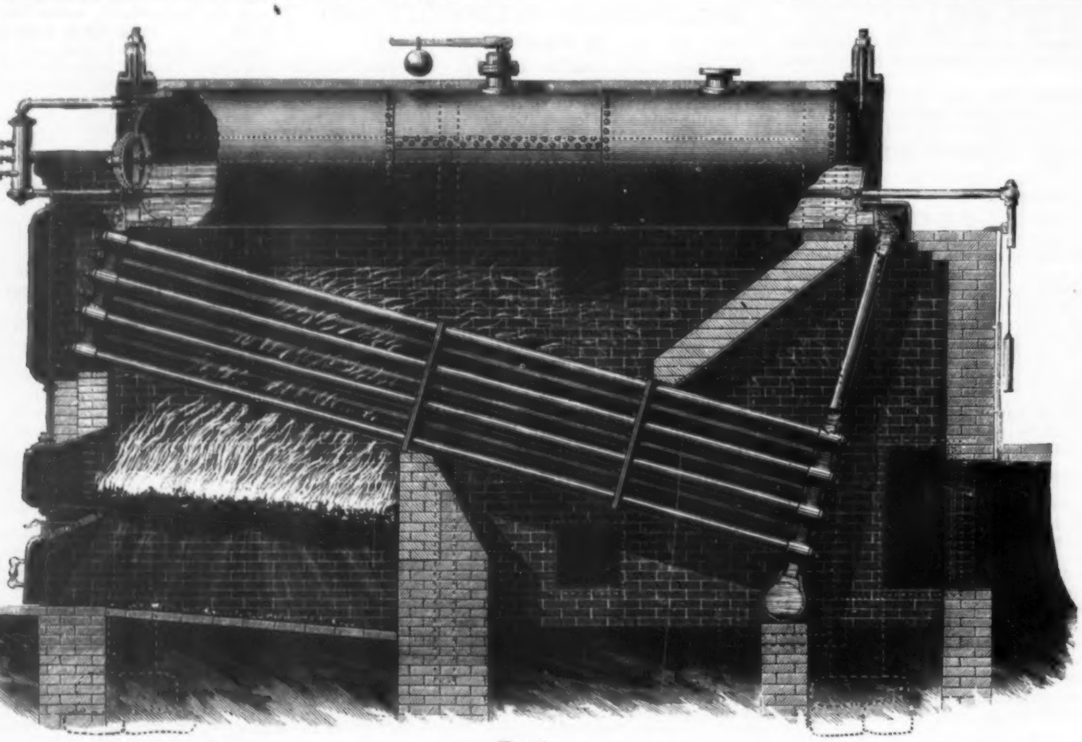


Fig. 1

In the sectional boiler, however, in some of its forms and varieties, the consideration of safety is satisfied at the sacrifice of others but little less important; and it has been largely true that the purchaser of a sectional steam boiler finds upon trial that his security is purchased at a high price, in the extra amount of fuel consumed, a short-lived boiler, heavy expenses for repairs, or other annoyances which cannot be represented in money value.

The boiler shown in the figures, possessing as it does all the security which inheres in the sectional type, has some especially commendable features which have, to a large extent, been found wanting in this type of boiler, and which, indeed, have heretofore taken the form of problems most difficult of solution in connection with them.

It is extremely simple, and consists merely of a group of tubes set at a considerable inclination, connected at each end by a kind of manifold chamber, and these in turn connecting by vertical tubes to the corresponding end of one or more cylindrical drums, placed horizontally above them. The drums are of such moderate diameter as not to detract from the sectional character of the boiler, but have very considerable steam space and water surface, from the fact that they extend the entire length of the boiler. The lower half of these drums are inclosed in the brickwork and constitute a part of the heating surface; but they are so far removed from the direct influence of the fire, and the gases are so largely deprived of their heat in their passage through (between) the tubes—which latter, of course, constitute the principal heating surface—that they are subjected to only moderate extremes of temperature, and as they are constructed under an abundant factor of safety, are practically as secure against rupture as the smaller tubes upon which the flame directly impinges. The water level is carried about at the center of the height of the drums, giving not only an abundant surface for the disengagement of steam, but ample steam room as well; both of which latter considerations are those in which the sectional type of boiler falls generally short of filling the bill. Aside from the opportunity given, the water mechanically thrown into the steam drums with the steam formed in the tubes to subside to the general level maintained, foaming, as ordinarily produced in boilers having insufficient steam room, by sudden or large draughts made upon the steam within it—that is to say, within the drum itself in this case—is prevented by the abundant space above the water; while the considerable body of water and large disengaging surface renders the maintenance of the water level an easy thing to do; and this is the most uncertain of all things in some sectional boilers. The inclined tubes being always filled with water, and being set in staggered rows such as to deflect the hot gases upon almost their entire circumference in passing between them, they constitute the most effective heating surface possible. The gases are made by means of transverse walls and diaphragm plates, as shown in Fig. 1, to traverse the nest of tubes three distinct times on their passage to the chimney; and are not only thus deprived of all the heat which it would be profitable to take from them when using the natural draught, but they are forced to make their first excursion at the higher end of the tubes, and their last at the lower end; and this, as we shall see further on, subserves an admirable purpose in the general arrangement.

Fig. 2 is a rear elevation part in section, and Fig. 3 is a front elevation showing the arrangement of casing, doors, and appurtenances.

The general form of the structure constituting the boiler, as will be seen in Fig. 1, is a right angled triangle, having for the two sides, including the right angle, the inclined nest of tubes and the back connecting tubes, and for its hypothenuse the steam drums. There are no natural forces known to us, which are more powerful than the expansion and contraction of metals through variation in temperature; in fact, they are irresistible by the expanding materials themselves, which are among the strongest of substances we have to deal with. Now, in structures of this kind having separate members in the same line of strain, and subjected to considerable variation of temperature, as will occur with a boiler between the periods of use under steaming conditions and when cold, and having a part of these members receive higher temperatures than the others, as where part have water in them and others only steam, the strains brought within the structure itself cannot be other than destructive; and we see that the keeping tight of the various kinds of joints connecting such members has been a fruitful source of trouble in the sectional boiler. With this boiler, it will be seen that, as the tube nest is always filled with water, and the gases pass across them three times, every tube will be expanded or contracted practically alike, one end of all the tubes being made hotter than the other, but all heated or cooled alike; so that, so far as the groups of tubes among themselves is concerned, there are no destructive strains brought upon them from this cause. But between the ranges of temperature which the boiler must undergo from time to time, the tube nest will necessarily suffer the greater expansion and contraction, being subjected to the hottest part of the fire; and with the triangular form of the whole, as shown, either one or two sides of the triangle may suffer the small change of dimension due to the change of temperature, without anything more than a proportionally small transverse strain upon the other side or sides, which, in such a case, would be far within their elastic limit, and consequently productive of no ill results.

Another important feature in this boiler is the perfect manner in which the principle of convection together with the formation and escape of the steam itself is availed of to give a rapid circulation to the water. The tubes being placed at so considerable an inclination and being below the cooler steam drum, the natural convection currents of the water would be such as to cause it to pass continuously from the back end of the drum to the lower end of the tubes, and from the upper ends of the tubes to the steam drum; but the rapid formation and escape of steam from the upper ends of the tubes will, of course, carry, mechanically, considerable quantities of water with it, increasing the rapidity of the circulation largely; and just here is where the drum subserves its best purpose. Rapid circulation of itself will tend to mix the steam and water, and in all boilers which have rapid circulation with a limited steam room and small disengaging surface, the more rapid the circulation the wetter will be the steam furnished by it. But rapid circulation is indispensable to prevent deposition of saline and sedimentary matters upon the water surfaces, and for an effective transfer of heat to the water, and in order to have it and dry steam from the same boiler, a proper and ample space must be provided for the subsidence of the agitation, and sufficient water surface to permit of the quiet disengagement of the steam from it. The drum in this boiler forms just such a place, and is the more effectual from the fact that the ebullient mixture of steam and water is projected into its front end from the tubes, and the quiescent steam with the water all drained out of it is delivered to the engine from the other.

That such is naturally the operation of this arrangement, is proved by the tests lately had at the Exhibition. The results of them show that, notwithstanding there is not an inch of superheating surface in this boiler, it delivered

practically dry saturated steam, containing the heat units due the temperature and pressure.

Connected to the lower ends of the tubes, running transversely of the nest, and placed a little out of the current of circulation is a small drum, seen in Fig. 1, for the collection or sediment from such water as may contain it, and occupying, as it does, the only place in the boiler at which the water can come to rest, if there is a deposit of mud or sediment anywhere within it, it must be at this point. Detachable bonnets are placed upon its ends, the removal of which permits of the extraction of the mud from time to time, as may be required. The steam drums are also provided with manholes and plates, through which their interior may be examined.

The tubes are lap welded and are expanded into the connecting chambers, which latter are steel castings; and ample provision is made for access to the interior of the tubes through openings in the steel chambers opposite their ends, which are closed by means of caps, accurately fitted, metal to metal, and these, having no organic or perishable material interposed for the purpose of making a joint, should be tight and give no trouble.

The removal of dust, soot, and ashes from the fire surfaces is provided for by openings in the side walls, through which this operation may be performed.

A very excellent feature in the setting of this boiler is that the entire metallic combination is suspended from transverse girders which are supported by cast iron columns, as shown in dotted lines in Fig. 1, which precludes the straining and cracking of the walls from the expansion and contraction of the metallic members. This is no small consideration, as fissures in the brick setting of boilers often causes serious loss of fuel by the leaking in of cold air at improper places.

The prevention of cold air leaks seems to have been well looked to, also, in the design of the iron front, a place where it is often neglected.

This part of the structure is, too, of a very tasteful and ornamental design; and, as a whole, it bears evidence of careful thought and a well considered application of correct principles. Below will be found the data and the results of the tests had at the Exhibition as I have computed them from the logs taken at the time; and they show that its efficiency and capacity are fully up to the mark. Prof. Thurston has said: "A boiler evaporating more than ten or eleven pounds of water per pound of coal" (in which he doubtless means from and at 212°) "including even all water joined, is to be looked upon with great distrust;" which, if correct, places the efficiency of this boiler at the highest place at which we may be satisfied of a correct interpretation of its performance.

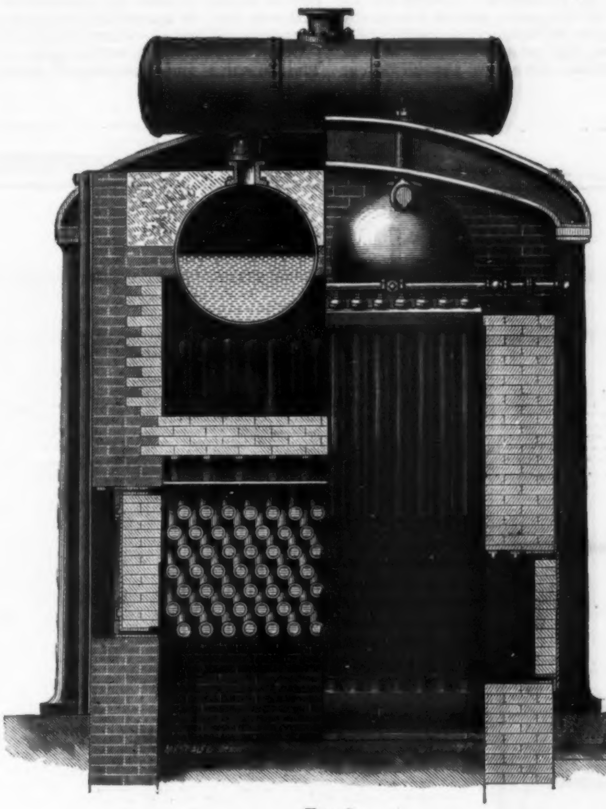


FIG 2.

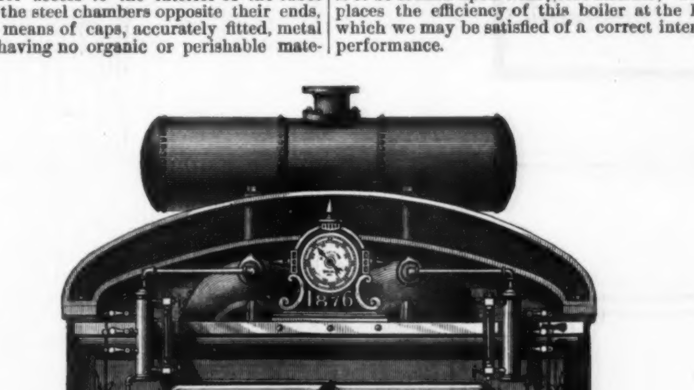


FIG. 3.

NORMAL TEST.

Heating surface (square foot)	1680·
Grate " " "	45·
Total coal burned (lbs.)	3555·55
" combustible burned (lbs.)	3164·55
Coal per sq. foot of grate, per hour (lbs.)	9·876
Total water fed (lbs.)	32442·
Per cent. of water primed	2·289
HP (30 lbs. of dry saturated steam per hour, from and at 212°)	155·71

POUNDS OF WATER EVAPORATED INTO DRY SATURATED STEAM.

From the temperature of feed (63°·98) *at* 70 *lbs. pressure.*

Total	31699·2
Per pound of coal	8·915
Per " " combustible	10·017
Per sq. foot of heating surface per hour	2·35
" " grate " "	88·05

From and at 212°.

Total	37870·
Per pound of coal	10·510
" " " combustible	11·809
Per sq. foot of heating surface per hour	2·78
" " grate " "	103·80

FORCING TEST.

Heating surface (square feet)	1680·
Grate " " "	45·
Total coal burned (lbs.)	5405·
" combustible burned (lbs.)	4081·
Coal per sq. foot of grate per hour	15·013
Total water fed	43535·75
Per cent. of water primed	0·213
HP (30 lbs. of dry saturated steam per hour, from and at 212°)	214·55

POUNDS OF WATER EVAPORATED INTO DRY SATURATED STEAM.

From the temperature of feed (57°·79) *at* 70 *lbs. pressure.*

Total	43442·8
Per pound of coal	8·037
" " " combustible	8·722
Per sq. foot of heating surface per hour	3·232
Per " " grate " "	120·67

From and at 212°.

Total	51492·8
Per pound of coal	9·527
" " " combustible	10·337
Per sq. foot of heating surface per hour	3·881
Per " " grate " "	143·04

J. T. H.

BOILER EXPLOSIONS, FROM SEPTEMBER, 1876, TO APRIL, 1877.

Thresher.—A horrible accident occurred on Saturday, September 30, near Plymouth, Ind., which resulted in the death of five persons, on the farm of William Johnson. The accident was caused by the explosion of the boiler of an engine connected with a threshing machine. The following persons were killed: A. W. Johnson and two of his sons, a young man named Sturgeon, and David Logan. The body of the last named could not be found, and is supposed to have been blown to atoms. Lack of water in the boiler was the cause of the explosion.

Portable.—A portable boiler near Charlotte, N. C., exploded October 5, tearing out the crown sheet, and destroying the boiler.

Nail Mill.—On the morning of October 12, a terrible explosion occurred at Zug & Co's mill, corner of Thirteenth and Etna Streets, Pittsburgh, which was attended with great loss of life. The boilers in the nail mill exploded. That building and more than half the rolling mill was shattered to pieces. At the time of the explosion there were employed in the nailing department 150 men and boys. The explosion literally tore the building to pieces. The roof was raised, and, in falling, it fortunately rested on the nail machines, enabling most of the workmen to crawl out and escape before the fires from the furnaces caught the mass of the wreck. Killed: Thos. Murphy, fireman; Andrew Sullivan, fireman; Frank Cupps, Peter Kendrick, John and Joseph Anderson, feeders; two brothers named McCafferty, and an unknown man, whose head was blown off. Frank Mangus, Andrew Mangus, and Louis Schroak, have died from their injuries, and Pat Griffin, John Higgins, and James Loper. Wounded: Reitzell, arm broken; M. Eberhart, badly scalded; Barney F ly, head and arm injured; Marcellus Snyder, a boy, head c.ushed seriously; John Snyder, leg and back seriously injured; Elmer McGoal, badly cut about the head; James Boyd, arm fractured; Otto Crook, ribs fractured; Fred. Richer, John Brosey, John Martin, and Wm. Kreppe, seriously cut about the head; Simon Bolard, arms and legs broken; Thomas Donnelly, badly cut about the head and body; Bowen, badly cut about the head and face; Wendell Ubbelhart, head and body hurt; T. Mackey, John Smith, and Michael Sullivan, fatally injured; —— Kendrick, both eyes blown out

Steamboat.—The boiler of the steamboat Matamoras exploded near Morgan's Point, on the morning of October 14. Three of the crew were killed and two wounded. After the explosion the boat was burned. Loss $20,000, uninsured.

Coal Mine.—About 3 o'clock, on the morning of October 17th, a nest of boilers at the Edge Hill shaft, Carbon Hill mines, exploded, killing George Smoot and Isaac Howell, and fatally injuring Benj. Ford, all employees of the mining company. The mines are 13 or 14 miles from Richmond, and are situated between the river road and the canal. There had been under this shed 13 large boilers of a capacity of 300 horse power. They were used to supply steam to pump the water out of the pit and hauling cars out of the pit up an inclined plane. Eleven of these boilers were in use, and 4 or 5 of them were utterly wrecked. The two colored firemen on duty at the time escaped unhurt. Ben Ford, the night foreman, who was superintending the hands at work in the pit, finding that there was not steam enough furnished to run the pumps, walked out of the pit up the incline to the boilers. When he got there, the water was found to be low in one nest of 4 boilers, and immediately on turning it on they exploded. The boilers blown up were in good condition—had,indeed,but recently undergone thorough overhauling and repairing. From the examination made, it is believed that when the boilers exploded the iron must have been red hot.

Flour Mill.—The boiler in a flour mill at Marcellus, Ohio, exploded Thursday, October 27, killing three men outright, fatally injuring two others, who were in the mill, and scalding a number of other persons.

House of Correction.—Soon after 12 o'clock on Sunday afternoon, October 29, a large boiler in the House of Correction, used for furnishing the female department with hot water, burst with a loud report, and shattered to atoms the window glass and sash immediately around it. Fortunately the inmates were in another part of the building eating dinner, and were, therefore, saved from injury.

(*To be continued.*)

THE U. S. IRON LANDING PIER, NEAR LEWES, DELAWARE.

By A. Stierle, C.E., Assistant Engineer.

The Delaware Breakwater Harbor, situated at the mouth of the Delaware Bay, and near Cape Henlopen and the town of Lewes, is well known as a great harbor of refuge. In 1873 alone, 17,490 vessels found shelter here, mostly from the storms of the Atlantic coast; a number for which the area of the harbor was at times wholly inadequate, and of which, fifty years ago, the constructors of the works of this artificial roadstead had no conception. Since the development of the petroleum and grain trade with Europe, this harbor has also become a stopping place, or call station, for ing upon cast iron foundation-screws—until now the only work of its kind in the United States.

Already during the early time of the construction of the breakwater—a work forming a long artificial sea wall of rough heavy stones on the open or north-east side of the harbor, and commenced in 1831 until completed, after irregular intervals, in 1869—the United States government was aware of the necessity of a wharf for the then vastly increasing shipping of the harbor. A pier of considerable magnitude was consequently built, about forty years ago, by the late General R. Delafield, U. S. Engineer Corps; but the pier, built as it was upon wooden piles, after it was discovered that the causes tending to its destruction could only be avoided at an enormous cost, was permitted to go to ruin: the ravages of the *teredo navalis;* the almost annually occur- harbor, to be built, generally, upon stone piles, and conforming in plan to the outline of the letter T. The stone piles, or piers, were to rest upon iron screw-piles.

In 1864, Lieut.-Col. H. Brewerton and Capt. F. E. Prime, of the Engineer Corps, under a resolution passed by the Senate of the United States, reported two plans, with estimates of piers, to be built at the same place. Their first project was similar in many respects to the one proposed by Col. Newton; their second project was a plan of an iron pier, to rest either upon hollow iron piles, from four to six feet in diameter, sunk by atmospheric pressure and filled with concrete; or upon solid iron screw-piles, six inches in diameter, and braced by three-inch bars.

Congress was slow in acting upon the projects submitted. The Junction and Breakwater Railroad had meanwhile

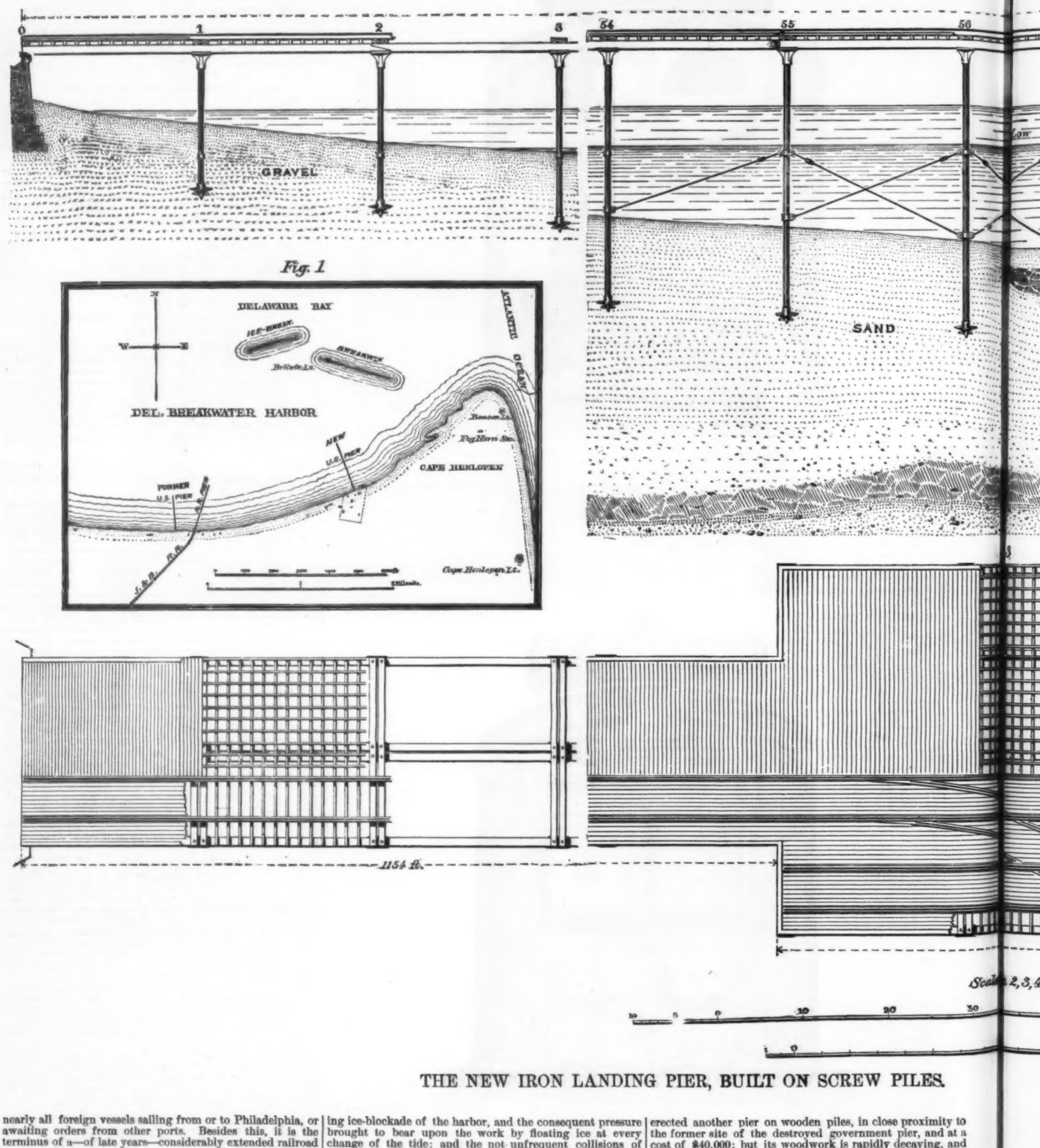


Fig. 1

THE NEW IRON LANDING PIER, BUILT ON SCREW PILES.

nearly all foreign vessels sailing from or to Philadelphia, or awaiting orders from other ports. Besides this, it is the terminus of a—of late years—considerably extended railroad system, which, under the management of a powerful company—the Old Dominion Steamship Company—has imparted a fresh impetus to fruit growing, the raising of farm and garden products, and to the general development of the lower section of the peninsula comprising within its boundary the whole of the State of Delaware, and the eastern shore of Maryland and Virginia.

Within the last six years an extensive work, embracing many novel features of engineering, has been erected in this harbor. It is a pier built on solid wrought iron piles, resting ice-blockade of the harbor, and the consequent pressure brought to bear upon the work by floating ice at every change of the tide; and the not unfrequent collisions of vessels with the pier, driven against it, and sometimes through it, during strong northwest gales—each of these causes was sufficient to demolish within a short period such a structure, erected in such an exposed locality. To-day, not a vestige of this pier is left, and its former position can only be ascertained with the aid of charts of the harbor of a comparatively recent date.

In 1859, Lieut.-Col. John Newton, Corps of Engineers, U. S. A., in compliance with instructions from the Chief of Engineers, presented a project for a landing pier at the same erected another pier on wooden piles, in close proximity to the former site of the destroyed government pier, and at a cost of $40,000; but its woodwork is rapidly decaying, and the expense of defraying the most necessary repairs is continual and very great. Finally, to satisfy the demands of the surrounding country as well as the increasing shipping of the harbor; also, in view of the probable erection of works of defence in its vicinity by the government, and the great advantages the United States Navy would derive from such a structure in case of war, as an adjunct to a coal station near by, Congress appropriated the sum of $225,000 during the session of 1870, "for the construction of a good and substantial pier of stone or iron in the Delaware Bay, at or near Lewes."

Selection of the Site, and Reasons for Deciding upon an Iron Pier.

The law limited the pier to be constructed only so far as the nature of the material was concerned; whereas the exact location, and the general plan, was left entirely with the officer who was to design and take charge of the work, subject to the approval of the Chief of Engineers.

In all the previously submitted projects, which are mentioned above, from 9 to 14 feet of water was considered sufficiently deep enough for all vessels likely to resort to the pier as a landing place. But Lieut.-Col. J. D. Kurtz, Corps of Engineers, U. S. A., the successful designer and constructor of the new pier, differed from this, inasmuch as he recommended the pier to be located at such a point where, by additions, if necessary, the deepest water in the harbor could be reached. Accordingly, a point in the eastern part of the harbor was chosen (see Fig. 1), about 1¼ mile distant from the site of the former Government pier; and although it was feared that there the position of such a comparatively light structure would be one greatly exposed to the force of the incoming sea during northeasterly storms, it was decided upon, notwithstanding, as being the best place, because it was the only part of the harbor affording a greater permanency in the depth of the water and in the stability of the sea bottom, all other portions of the sheltered area being subjected to a deepening or shoaling process, caused by the changes in the currents since the breakwater was built.

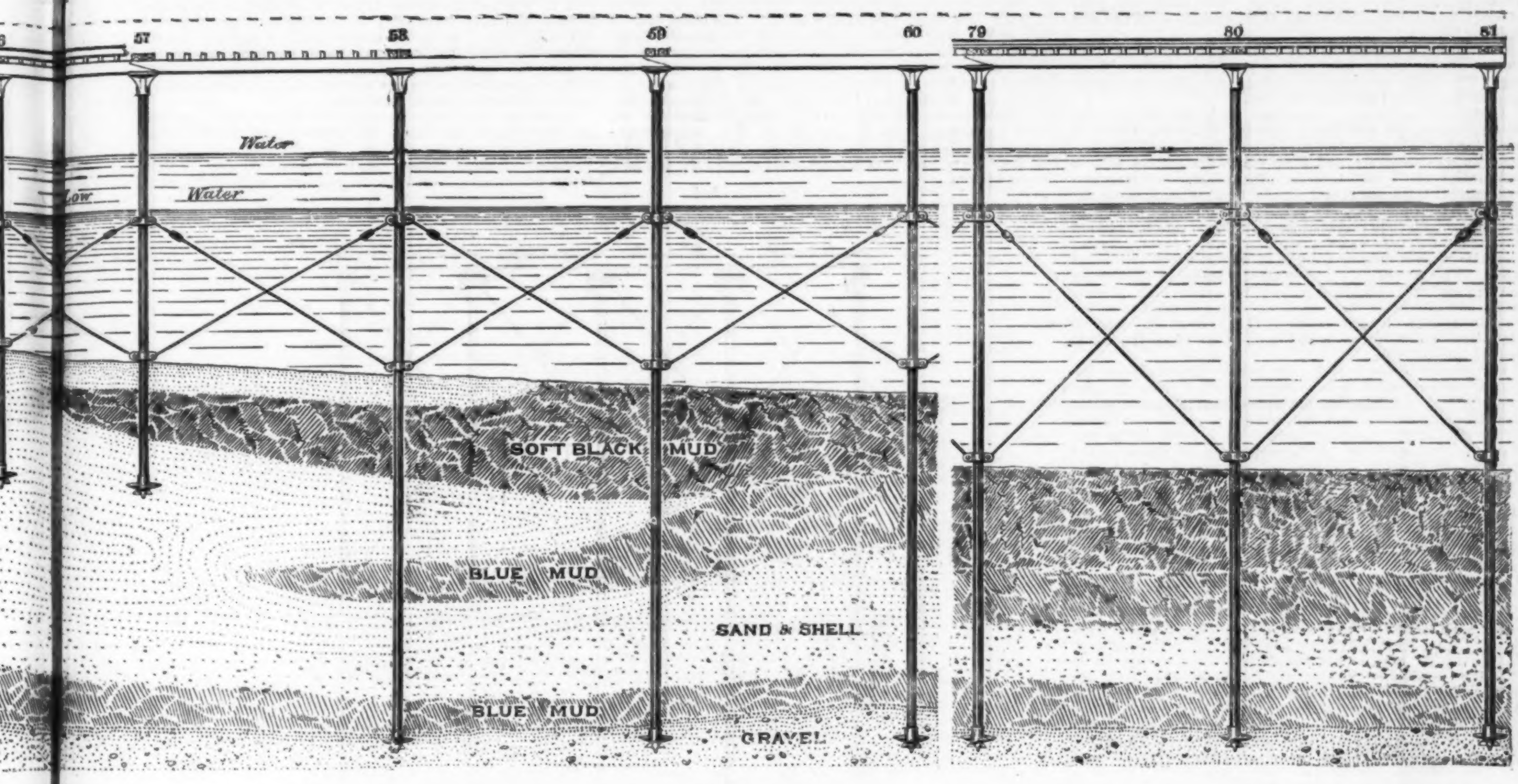
Successive surveys, made subsequently to the construction of the breakwater, showed a general shoaling of the harbor; they also indicated a proportionally less filling up in its eastern part, where a depth of 22 feet at low tide could be reached, with a pier 1,800 feet long. The selection of the site was finally approved by a board of engineer officers and by the Chief of Engineers, a counter-movement made at the same time, and led by the Junction and Breakwater Railroad, who had the privilege by law to extend their track over the new pier, and by others of the vicinity, having for its object the erection of the pier in the western part of the harbor, having failed.

After the point of location had been selected, it became necessary to determine upon the nature or kind of pier which was to meet or avoid all difficulties formerly met with, and which, even in its very foundation, was almost problematical through the ever-recurring changes of the sea bottom. For the better elucidation of the reasons which finally determined Col. Kurtz to adopt an iron substructure, consisting of wrought iron piles resting upon cast iron foundation screws, it will be best to quote the following remarks from his annual report for the year ending June 30, 1871:

"Stone and iron are the materials named in the law, between which a selection is to be made for the structure. A pier-head of comparatively small dimensions, isolated at the end of a long connecting bridge, is liable to receive the severest pressure of ice-fields and jams, as well as to be exposed to the accumulated force of large vessels lying alongside and riding against it with the roll of a moderate sea. Stone pillars of moderate dimensions, built in horizontal courses and resting upon a substructure of iron or other material, are liable to be disturbed by such an enormous mass in motion, while the cross dimensions of the stone work are still so large, and the interspaces so small, relatively, that floating ice will not pass through, but will accumulate against the pier-head and form fields of large extent. For these reasons, a long, narrow pier-head is proposed, and *iron is preferred as the material of the pier, in piles having no joint or horizontal plane of separation from top to bottom,* the lines of piles to be placed at short intervals apart, and the whole structure to be bound together by ties and braces, so as to receive the pressure of vessels and ice at a large number of points and distribute it through as many members as possible. In addition to this general arrangement, a series of pile fenders is proposed to be placed along the outer part of the structure, connected together by horizontal ties, but entirely disconnected from the members of the pier proper."

* * * * * * * *

"The position of the pier, having the deepest water, as indicated above, is necessarily more exposed to the action of the sea than those lying further up the harbor, where the water is shoaler. This would be a cause of anxiety if experience had not shown more satisfactorily than is the case with respect to ice, that no apprehension need be felt of injury being done to the structure by the force of the waves.



DESIGNED BY LIEUT.-COL. J. D. KURTZ, CORPS OF ENGINEERS, U.S.A.

In 1847, Alex. Mitchell, the originator of the iron screw-pile, was led to apply his invention to the construction of a landing pier near Courtown, on the southeast coast of Ireland. An open sea of seventy miles in front beats on the shore at the point selected for the work. It has stood without injury, and has shown that there need be no hesitation in applying his method in the heaviest seaway."

* * * * * * *

"The fact that the bottom is sand, without cohesion, and everywhere moving under the influence of the currents of the harbor, is a forcible reason for using *piles of the smallest cross-section* (wrought iron) instead of stone for the supports of the structure. Stone would require supports of considerable area, and these would either accumulate the sand so as to increase the shoaling of the water, or they would act as material obstacles, and quicken the currents to the danger of their foundations being undermined and cut away. Probably both results would ensue. The small iron piles produce no sensible disturbance of the condition of the currents or bottom."

For the top or superstructure of the pier two plans were submitted: one for an iron, and another for a wooden, flooring. The latter was finally adopted as being considered cheaper and more rigid than the first.

During the preliminary researches made for the purpose of ascertaining the sustaining capacity of the sea bottom, it was discovered that the soil into which the piles of the pier-head were to penetrate, and upon which the screws, after a penetration of 10 feet, were to rest, was of a very treacherous nature. Continuous and careful borings made along the proposed pier-line with an artesian-well boring apparatus and a four inch tube revealed the fact that a safe foundation —which in this case was a stratum of very coarse gravel— could be reached only at a depth of 64 feet below low water mark. This would have necessitated a length of 75 feet for the pile shafts of the pier-head—a discovery which, in view of the enormous cost this would engender, formed at once a very formidable obstacle to the carrying out of the original plan, and which, for a while, seemed to make the whole project questionable.

Fortunately it was found, after the investigations of the bottom were extended in a westerly direction from the original line, that is, further up the harbor, that the above gravel stratum had a considerable dip, so that it could be reached by the piles of the pier-head already at a depth of 43 feet below low water mark, if the outer end of the proposed pier-line—still having the same initial point on shore—was swung about 900 feet to the westward.

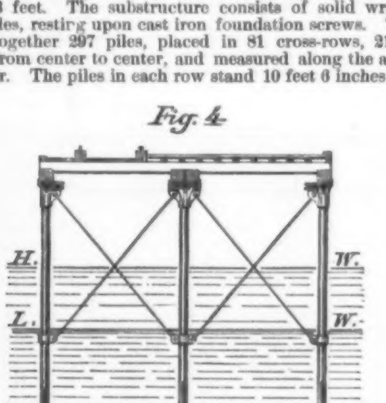
This line, although affording less depth of water at the pier-head, was finally adopted as the line along which the pier was built, and which, in the character of its bottom, presents one of the most interesting features of the work.

General Description of the Pier.

(a) The Substructure.

The total length of the pier (Figs. 2 and 3), measured from the zero point on the abutment, is 1,702 feet. The width of the narrow or bridge part, which is 1,154 feet long, is 22 feet; that of the pier-head, for the remaining distance of 548 feet, 43 feet. The substructure consists of solid wrought iron piles, resting upon cast iron foundation screws. There are altogether 297 piles, placed in 81 cross-rows, 21 feet apart from center to center, and measured along the axis of the pier. The piles in each row stand 10 feet 6 inches apart

Fig. 4



THE NEW LANDING PIER. DELAWARE BREAKWATER.

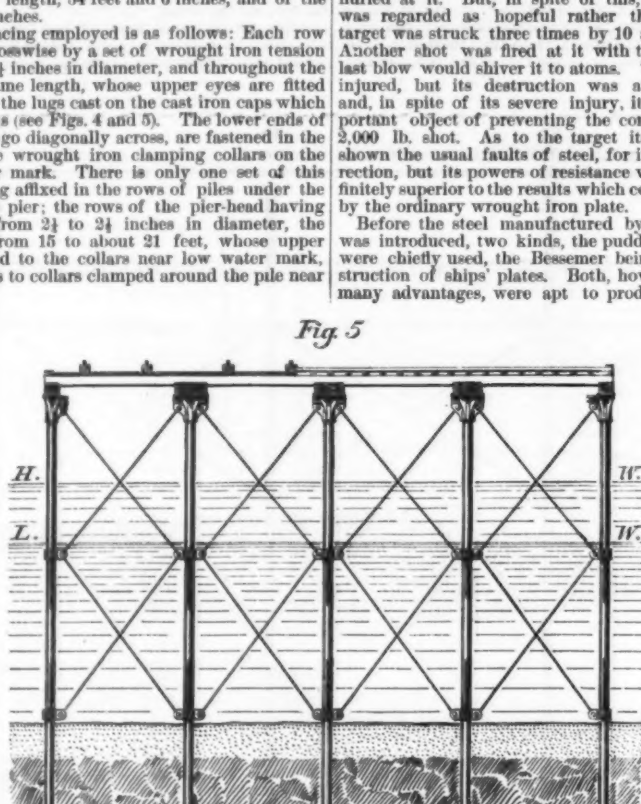
from center to center. Fifty-four rows of piles, those under the narrow part of the pier, have 3 piles each (see Fig. 4); and the 27 rows supporting the pier-head have 5 piles in each row (see Fig. 5). The length and the diameter of the piles, whose tops were placed at the uniform level of a fraction less than 11 feet above mean low water, was made to conform to the profile and to the character of the bottom, assuming a general penetration, where possible, of 10 feet. From the first to the forty-ninth row, the diameter of the piles is 5¼ inches; the length increasing, more or less, from 16 feet to 25 feet. For the next five rows, from the fiftieth to the fifty-fourth inclusive, the diameter is 5¾ inches; the length, as the water is now getting deeper, rapidly increasing from 25 feet to 29 feet 6 inches. The next row, the fifty-fifth, is the first row of the pier-head. In this and the two following rows, the fifty-sixth and the fifty-seventh, the diameter of the piles is 6¾ inches; their length, for the rows named, being respectively 31, 32½, and 33½ feet.

At this distance, 1,200 feet from the zero point of the pier, the bottom of hard sand into which, so far, the piles had been inserted to a depth of 10 feet, changes suddenly into a stratum of soft black mud (see Fig. 2). Indeed, there the whole bottom to a great depth seemed to have undergone a perfect transformation. It is a meeting point, so to speak, of the alluvial deposit of the sea and the sand of the seashore, which materials, in the same degree as one preponderated over the other during their oscillatory movements with the currents, finally formed successive strata of sand and mud to a depth of 30 feet. To trust to any of the intermediate strata of sand, which were thickly interspersed with shells and pebbles and still offered considerable sustaining capacity, as experiments had shown, would have been combined with great risk, overlying, as they did, beds of soft blue clay and mud, from 4 to 8 feet in depth. It was therefore thought best to rest the flanges of the foundation screws upon the coarse gravel stratum which was extant lower down and well determined by previous borings, and which, singularly enough, presented an almost level surface in the direction of the pier at an uniform depth of 43 feet below low water line.

The remaining piles of the pier-head, from the fifty-ninth to the eighty-first row inclusive, were consequently designed of the same length, 54 feet and 6 inches, and of the same diameter, 8¼ inches.

The system of bracing employed is as follows: Each row of piles is braced crosswise by a set of wrought iron tension braces from 2 to 2¼ inches in diameter, and throughout the pier of nearly the same length, whose upper eyes are fitted and bolted between the lugs cast on the cast iron caps which carry the floor beams (see Figs. 4 and 5). The lower ends of these braces, which go diagonally across, are fastened in the same manner to the wrought iron clamping collars on the piles near low water mark. There is only one set of this vertical cross-bracing affixed in the rows of piles under the narrow part of the pier; the rows of the pier-head having an additional set, from 2¼ to 2½ inches in diameter, the length increasing from 15 to about 21 feet, whose upper eyes are also fastened to the collars near low water mark, and their lower ends to collars clamped around the pile near the sea bottom.

Fig. 5



THE NEW LANDING PIER. DELAWARE BREAKWATER.

Another set of diagonal braces connects the piles in the direction of the length of the pier. It was thought proper, on account of the shallowness of the water under the bridge part of the pier where the floor itself offered sufficient rigidity between the rows of piles, to dispense with this longitudinal bracing until deep water was reached. Consequently, they commence only at the fifty-fourth row (see Fig. 2), and extend from there to the outer end of the pier. These braces, from 2½ to 3 inches in diameter, become larger, like all other braces, in proportion as their length increases from 20 feet to 27 feet 6 inches. They are placed under water to avoid obstructing the bays of the pier, or affording a resting place for ice to form upon or lodge against, and extend diagonally and longitudinally with the pier from the same collars to which the lower cross-braces are fastened near low water mark to those near the sea bottom.

We shall, in our next, present further engravings and details, covering the construction in full.

STEEL SHIPBUILDING.

The determination of the Government to construct, not experimentally but wholesale, several war ships of steel, is a sufficient indication that one of the most obstinate difficulties in shipbuilding has been overcome. Although the Iris and Mercury, which are now under construction at Pembroke, and are rapidly approaching completion, are the first steel vessels built for the Royal Navy, many years have elapsed since the effort to employ steel for this purpose was first made. Indeed, it may almost be said, without exaggeration, that, from the first application of iron to ships of war to the present time, uninterrupted attempts have been made to substitute steel for iron. But the difficulties were found almost insuperable, as experiment after experiment proved the impossibility of overcoming the defects which excluded steel as a material for shipbuilding. The reward of success, however, was known to be most valuable, and such as to justify the most unwearied efforts. By substituting steel for iron, a more sparing use of metal would be possible, with the corresponding result of insuring a reduction of weight, an increase of speed, and a possible reduction of cost. Steel has greater ductility or elasticity than iron, while in tensile strength or toughness it possesses in its ordinary form a power 50 per cent. greater than its rival. The anxiety of naval architects is, therefore, intelligible. With the extravagant and rapidly increasing use of iron in ships of war, it was worth any effort to discover some means of utilizing such a substance as steel, with properties so far superior to iron and so peculiarly applicable to naval construction. But it had a defect which was fatal. There seemed to be no means of overcoming its fragility; and its tendency to crack raised an insuperable objection to its use. Although, therefore, for years it has been largely used by shipbuilders, for various purposes, it has not until very recently superseded iron. During the experiments with the 100-ton gun at Spezzia, it may be remembered that the steel target was severely cracked and fissured under the blows of the shot hurled at it. But, in spite of this, the result of the trial was regarded as hopeful rather than the reverse. The target was struck three times by 10 and 11 inch projectiles. Another shot was fired at it with the expectation that this last blow would shiver it to atoms. The plate was severely injured, but its destruction was anything but complete; and, in spite of its severe injury, it effected its most important object of preventing the complete penetration of a 2,000 lb. shot. As to the target itself, it appears to have shown the usual faults of steel, for it had split in every direction, but its powers of resistance was remarkable, and infinitely superior to the results which could have been achieved by the ordinary wrought iron plate.

Before the steel manufactured by the Siemens' process was introduced, two kinds, the puddled and the Bessemer, were chiefly used, the Bessemer being superior in the construction of ships' plates. Both, however, in spite of their many advantages, were apt to produce much disappointment in actual use, and could not be relied on in the construction of ships of war. In merchant vessels, where the requirements were not so exacting, steel has been largely used, and the following regulations approved by Lloyd's Committee, and quoted by Mr. Reed in his book on "Shipbuilding in Iron and Steel," are of interest and importance:

"That ships built of steel of approved quality, under special survey, be classed in the register book with the notation 'experimental' against their character. In all cases, however, the specifications for the ships must be submitted to the Committee for approval. That a reduction be allowed in the thickness of the plates, frames, etc., of ships built of steel, not exceeding one-fourth from that prescribed in Table G for iron ships. In no case, however, are the rivets to be made of steel, nor will any reduction be allowed in the size of rivets from those described in Table G for ships of the same tonnage, built of iron. In other respects, the rules for the construction of iron ships will apply equally to ships built of steel."

The saving in weight is one of the most important recommendations of steel; and when this is known to have amounted to about 100 tons for every 1,000 tons (builders' measurement), the temptation to substitute steel for iron will be appreciated. The most enterprising and successful manufacturer for many years was Mr. Bessemer; and, in spite of constant disappointment and failure, he applied himself to overcome the difficulties which obstructed him, and seemed doomed to prove insuperable. The expense of Bessemer steel, which was about £1 per ton more than puddled steel, was a serious drawback to its general use; but its superiority for certain purposes was undeniable. As far back as 1864, the Admiralty considered seriously the propriety of using steel in the construction of ironclads, and conducted an important and extensive series of experiments at Chatham Dockyard. The results were, however, on the whole, disappointing, though in some respects they may be considered interesting. The material used was Bessemer steel, and the conditions of its trial was to stand 33 tons per square inch and 30 tons crosswise. The details of this trial are given by Mr. Reed, but cannot conveniently be quoted. He considers that "the results were very remarkable. The material was shown to have one-third more strength than was expected, when it fractured fairly; but it was also shown to have an erratic mode of fracturing, which caused a variation in the breaking strain per square inch of original area between 43¾ tons and 25¼ tons; or, regarding the fractured area,

there is a variation between, say, 15 and 60 tons." The fracture of most of the plates, and at repeated trials both at Chatham and Pembroke, at the rivet-holes, showed clearly the danger and uncertainty to which ships would be exposed if constructed of this metal. Another source of danger discovered itself in the Hercules, at Chatham, which was the source of controversy and curiosity at the time. One of the upper deck-plates, made of half-inch Bessemer steel, was found one morning completely cracked, without warning and without any apparent cause. The workmen could not account for it, and were at loss whom to suspect of having committed an apparently wanton act of mischief. It appeared, on inquiry, that it had been riveted into its place on a hot day and during the heat of the day; that an unusually cold night had followed, and that next morning the brittle plate had broken in two.

One of the results of these numerous experiments was to arouse the ingenuity of inventors and manufacturers, and stimulate them to discover some process of counteracting the destructive effects of riveting, or, rather, of drilling holes for the introduction of rivets. Most of them took the form of exposing the metal to a further process of manufacture after it had been punched and prepared for actual use in any vessel. Annealing was proposed, and was found to a large degree successful. At the Hoërde Steel Works, in Prussia, Mr. Rochussen tried the experiment of a melted lead bath for this purpose. His process was proved very successful in toughening and hardening steel. It was adopted at Woolwich in the manufacture of gun tubes. Here, however, oil was used in the annealing process. None of these efforts proved, however, sufficiently successful to induce Naval Constructors to employ steel in shipbuilding, except in an unimportant way. Indeed, after it had been used in this way for some years, it was for nearly five years altogether abandoned as unprofitable. Yet progress was being made in this period, and the result of experiment, though not conclusive, seemed to warrant the hope, which was soon converted into a certainty, that a satisfactory method of manufacturing steel fit for the construction of men-of-war would be found. At last, at the Landore works, by a process adopted by Dr. Siemens, steel was produced which answered the required conditions, conquered the skepticism or critical exactions of the Admiralty Constructors, and induced the Government not only to commence two corvettes at Pembroke, but to order shortly afterwards six smaller vessels, which are to be built of steel. Dr. Siemens himself, speaking on the subject in 1875, when doubt still existed as to the possibility of using steel for shipbuilding, expressed the greatest confidence in success. "Steel," he said, "is a material belonging to a group varying between the hardness of the diamond and the toughness of copper, and it is also of the highest importance that the manufacture throughout and the construction throughout should be carried on with superior intelligence. Now," he asks, "should we shrink from using a material because intelligence is required in working and using it? Surely that would be a very poor compliment to this age of progress. We should have no difficulty in finding what are the conditions necessary to produce steel of such and such a quality, and should see to it that we obtain this quality and obtain it always." Further on he remarks that "in making steel we formerly dealt with it in small quantities, also by melting it in pots, but Mr. Bessemer has first shown us how to deal with it in large quantities in his converter. I have had," he continues, "considerable experience in dealing with it in large quantities in the open hearth furnace. There, I know, we can produce six, or eight, or ten tons of steel, of perfectly uniform quality. We can take out samples before pouring that steel to assure ourselves of having the quality desired. This metal is thoroughly mixed—it is a perfectly fluid mass—and, therefore, there can be no reason why there should be a difference in the behavior of one part of this metal from the behavior of another part. Now," and he here approaches the point of importance in naval construction, "I have lately seen steel of a very mild quality produced which is eminently suitable for structural purposes. This steel contains hardly any carbon at all—perhaps one-tenth per cent. only; but it contains manganese in a larger proportion than has been given to it hitherto. It is possessed of a toughness which is unapproached by any other kind of metal; and before it breaks it yields even to 50 per cent. Now, if such a material can be produced, and if such a material will resist, say, 30 tons, which is quite enough for all purposes, I think that is the very best material for structural requirements." The importance of this statement is to be judged by the subsequent success Dr. Siemens has gained at his works at Landore, where steel has been produced of a quality fit for the construction of ships of war.

In a very interesting paper read before the Institution of Naval Architects in 1876, Mr. Riley, the manager of these works, published in detail the results of Dr. Siemens' experiments, and gave an analysis, really, of the steel now used in the construction of our new steel corvettes. Interesting as these experiments are, they cannot be detailed here, nor would the details be of much service without the help of illustrations. But we note the tests required by the Admiralty, which are given by Mr. Riley. They are to the effect that—"From every plate made a strip is to be cut, which, after being heated to a 'cherry-red' color, shall be plunged into water having a temperature of 82° Fah. After being thus cooled, the strip is to be bent, without fracture, until the radius of the inner curve equals not more than 1½ times the thickness of the strip. This is known as the 'tempering' test. Further, from each lot of 50 plates or angles, a piece is to be taken, and the edges having been planed parallel, its tensile strength is to be proved. To be satisfactory, this must not exceed 30 tons, nor be less than 26 tons on the square inch; and before fracture takes place there must be an elongation of not less than 20 per cent. on 8 in. of its original length." Under these rigorous, and, indeed severe conditions, 101 samples were tested, representing more than 5,000 plates or angles, and gave, with few exceptions, the most satisfactory results. One of the most important of them is that the Landore steel, after punching, shows a very small reduction in strength. Summing up the advantages this steel has over previous manufacture, Mr. Riley says:

"(a.) That it has nearly the same strength in both directions of the plate, and that is much greater than that of iron.

"(b.) That its ductility is equal to that of iron, and greatly superior to that of ordinary steel plates.

"(c.) That the resistance offered to impact, as shown in the percussion tests quoted, as well as in the specimens which have been submitted to the bulging and gun-cotton experiments, is superior to that of plates from either, say, good iron or ordinary steel.

"(d.) That the tempering, and consequent diminution of strength produced by shearing or punching is not as great as is the case with either iron or ordinary steels.

"(e.) That the surface of the plates being much smoother, the friction and consequent loss of power-speed of vessels built of this steel must be less than in the case of iron vessels; and

"(f.) That the superiority in strength of the plates made at Landore over iron, being so great, one of two results must happen in the case of vessels in whose construction these plates are used. Either they will be very greatly superior to iron vessels in strength, or their strength being reduced to that of iron, their weight must be equally reduced and the carrying capacity very largely increased."

The value here claimed for this steel has not been considered exaggerated. It is sufficient to know that it is now being used in the construction of Her Majesty's ships, and that it will shortly, in all probability, be used more extensively. But it is more important to know that its use has introduced a revolution in naval construction, and that, in the process Dr. Siemens has invented, a difficulty has been overcome which has baffled for years invention and experiment, while it opens a path for naval construction whose value we may foresee, but can hardly yet realize.—*London Times.*

DYNOGRAPH EXPERIMENTS.

THE dynograph car of the Eastern Railway Association, in charge of P. H. Dudley, has been running between Springfield and Worcester, on both freight and passenger trains, to test the relative amount of power required at different points along the road, especial reference being had to the Springfield and Charlton grades. The experiment on the Modoc train east, says the *Republican*, leaving Springfield at 6:30 A.M., which on the day in question consisted of two sleepers, four passenger and baggage cars, and the dynograph car, showed power required as follows: For the first 2,920 feet out of the depot the tension on the draw-bar was 6,526 lbs.; for the mile 6,460 lbs., the rate of speed being 32 miles per hour; for the next 6,200 lbs., the speed being 36 miles, and for the last 1,100 feet to the top of the grade 6,250 lbs. The last mile required the engine to produce 19,625,800 foot lbs. of power per minute, the term foot-pound indicating the power required to lift one pound one foot. In going up the grade from East Brookfield to Charlton, beginning at the station, the tension on the draw-bar for the first 3,880 feet was 5,722 lbs.; for the first full mile, the velocity being 37·5 miles, 4,280 lbs.; for the second mile, with 37 miles velocity, 5,232 lbs.; third, with 36 miles velocity, 5,450 lbs.; fourth, which contains a sharp curve, with 37 miles velocity, 5,612 lbs.; fifth, with 41 miles velocity, 5,230 lbs.; and, sixth, which ran a little past the summit at Charlton, 4,356 lbs. The engine had an 18x24 cylinder, and the track was in excellent condition. The maximum of the Springfield grade is 60 feet to the mile, and the Charlton grade 51·47 feet. At the sharpest curve the grade is about 49 feet. Similar experiments were made on a freight train of 27 cars drawn by the "Adirondack," famous for her trials with the Mogul engine last summer, and showed that the tension on the draw-bar going up Springfield grade at a speed of 5·9 miles per hour was about 16,000 pounds, and the average strain going up Charlton grade at an average speed of about 9 miles per hour was 14,500 lbs., the power required in the first instance being 84,840,000 foot lbs. Near the top of the grade the power of the engine was tested by applying the brakes, and it was found that, running at four miles per hour, the engine could exert a tension of 17,000 lbs. Beyond this point the drivers would slip, and made but little progress.

DEUTSCHE CHEMISCHE GESELLSCHAFT, BERLIN.

March 26, 1877.

Prof. B. BAEYER, Vice-President, in the chair.

PROF A. W. HOFMANN stated, in connection with the late communications "*On Mono-methyl Aniline,*" that he had obtained this compound by the action of methylic chloride, bromide, and iodide upon analine, the latter in excess. Dimethyl aniline, regarded by Kern as the sole product, is produced in equal proportions with mono-methyl aniline, when CH_3Cl is used, and in the proportion of 3:1 when CH_3I is used,—CH_3Br giving intermediary results. Mono-methyl aniline is obtained quite pure in the form of the acetyl compound by simple distillation of the products of the reaction with acetic anhydride. Commercial dimethyl aniline is found to contain in all cases variable amounts of mono-methyl aniline.

Prof. A. Baeyer communicated the latest results of his investigations "*On Phenol-Phthalein.*" By treatment with HKO it is decomposed into benzoic acid and dioxy benzophenon, $CO(C_6H_4OH)_2$, a body obtained in fine colorless crystals.

Prof. A. Baeyer also gave at length various theoretical considerations inclining him to bestow upon "*Furfurol,*" $C_5H_4O_2$, a constitutional formula in which four carbon atoms are joined together in a ring, as in the case of benzine.

Prof. O. Wallach described "*Chlorine Derivations of Aceto-phenon.*" By the action of chlorine alone, besides $C_6H_5COCH_2Cl$, he has obtained $C_6H_5CO_2Cl$. With PCl_5 aceto-phenon forms $C_6H_5CClCHCl$, which easily takes up two additional atoms of Cl and forms $C_6H_5CCl_2CHCl_2$.

By the "*Reduction of Chloralide*" he has obtained dichloracrylic acid, CCl_2CHCO_2H. This compound does not unite with two additional halogen atoms as would be expected, the presence of chlorine seeming to affect the additive properties of acrylic acid.

Prof. A. Oppenheim and R. Helon described "*Ethyl-propionyl Propionate,*" $C_2H_5CO.C_2H_4COOC_2H_5$, the next higher homologue of ethyl-acetyl acetate, obtained among a variety of condensation products resulting from the action of sodium upon ethyl propionate. It is a mobile liquid, with characteristic odor and taste, boiling at 200°, and dissolving sodium with ease. The authors were unable to separate out analogous compounds from the liquid products resulting from the action of sodium on ethyl butyrate and isobutyrate.

Prof. A. Oppenheim and T. H. Norton gave an account of a new acid, "*Thiorufinic Acid,*" $C_{10}H_{14}S_2O_4$, obtained by the action of CS_2 on the mixture of sodium ethylate; and sodium ethyl-acetyl acetate, resulting from the solution of sodium in ethyl acetate, and apparently a condensation product of xanthic acid, and the analogous derivative of ethyl-acetyl acetate. The acid and its salts crystallize in brilliant crimson needles. The salts of the heavy metals are exceedingly insoluble. Treatment with N_aOH yields alcohol, and a new acid likewise of a bright crimson color, and exceedingly soluble in water.

The same described also "*Carbo-thio-ethyl-acetyl Acetate,*" $CH_3CO.C(CS)COOC_2H_5$, obtained by the action of PbO and CS_2 upon ethyl-acetyl acetate. It crystallizes in yellow needles, and is sparingly soluble in ordinary solvents.

The following communications have been received from non-resident members:

F. Wöhler, "*On the Separation of Arsenic from Nickel and Cobalt.*" In order to avoid the precipitation with H_2S, the author dissolves the minerals to be analyzed in aqua regia, and adds Na_2CO_3. The precipitate is treated with oxalic acid, and the insoluble oxalates of the two metals thus obtained are easily and completely separated from the soluble arsenate.

E. Schunck and H. Rœmer, "*On Purpurin.*" The authors find that purpurin by heating to 300° is changed into chinizarin. Purpurin is also distinguished from analogous compounds by uniting with but a single molecule of bromine.

P. Friedlander, "*On Diphenylen-Glycollic Acid.*" This acid $(C_6H_4)C.(OH).(COOH)$, is obtained by the action of HNaO on phenanthrenquinon. By oxidation it yields diphenylen-keton $(C_6H_4)_2CO$; by heating with water, at 160°, benzhydrol $(C_6H_4)_2CH.OH$; and by reduction, diphenylen-acetic acid $(C_6H_4)_2CH.COOH$, which changes easily into fluoren.

H. Hübner and K. Buchka, "*On Phenoxylic Acid.*" By the action of the HCl on benzoyl cyanide, at 140°, the authors obtain a yellow crystalline compound—

$$(C_6H_5COCN)_2H_2O,$$

which yields, with alkalies or acids, phenoxylic acid—

$$C_6H_5COCOOH.$$

It crystallizes in colorless needles, melts at 111°, is very soluble in water, and forms crystalline salts.

L. Claisen describes an acid of the same composition, resulting from the action of HCl on C_6H_5COCN at an ordinary temperature, melting, however, at 66°.

F. Fittica, "*On Nitro-benzoic Acids.*" Additional particulars are given with regard to the fourth isomeric nitro-benzoic acid announced by the author in 1875. He has now succeeded in obtaining it by the action of ethylic nitrate on an ethereal solution of benzoic acid, in the presence of concentrated sulphuric acid. The acid melts at 127°, and is soluble in 380 parts of water. The free acid cannot be changed into its isomers by repeated crystallizations or heating beyond the melting-point. This change is, however, possible in the salts. The barium salt, after repeated crystallizations, yields with HCl meta-nitro-benzoic acid; melting-point, 142°. The ether was obtained by the slow action of ethylic iodide on the silver-salt at a low temperature. It forms yellow needles, and melts at 37°. The fourth isomeric amido-benzoic acid, obtained by reduction from the nitro-acid, melts at 156°, and in the form of the ammonium salt can be changed into metamido-benzoic acid by prolonged heating. Another nitro-benzoic acid, melting at 135°, prepared by the action of HNO_3 and H_2SO_4 on benzoic acid at a low temperature, is regarded as a physical isomer of the acid melting at 127°, because it possesses the same solubility and yields the same ether and amido-benzoic acid. The author has further obtained two nitro-benzoic acids possessing the same melting-points as meta-nitro-benzoic acid, 142°, and the fourth nitro-benzoic acid, 127°; but characterized by a greater solubility in water and by the bright lemon color of not only the acids but also the salts and ethers.

"*On Benzoic-nitro-benzoic Acid.*" This acid is prepared in the form of the ether, by the slow addition of an ethereal solution of benzoic acid to concentrate H_2SO_4. Saponification with potash yields the free acid. The author gives it the formula—

$$C_6H_5COOH.C_6H_4.NO_2.COOH,$$

and regards it as a molecular compound, although the ether can be distilled without decomposition. A similar acid was obtained from benzoyl-chloride and ethyl-nitrate. The author has successively applied the above-mentioned reactions for the preparation of nitro-acids to other aromatic acids.

M. Fileti and R. Schiff, "*On the Constitution of Cyanamide.*" By the action of chloral on cyanamide the compound $NC.NH_2C_2Cl_3OH$ was obtained, and by treating $CN.NAg_2$ with C_2H_5I diethyl cyanamide, $CN.N(C_2H_5)_2$, was prepared, from both of which reactions the authors regard the formula of $NC.NH_2$ for cyanamide as much more probable than NH.C.NH.

E. Von Sommaruga and E. Reichardt state, in a preliminary communication on the "*Action of Ammonia on Isatin,*" that they have obtained two crystalline bodies differing from those mentioned by Laurent in his investigations on the subject.

A. C. Christomanos, "*On Iodine-Trichloride.*" The best method for the preparation of this compound, free from iodine, is found to be that of mingling gaseous HI and Cl:—$HI+{}_2Cl_2=HCl+ICl_3$. The bright yellow trichloride thus obtained melts at 33°, and changes into a yellow gas at 47·5°. Chlorine gas is the only medium in which it can be preserved indefinitely. In air, oxygen, and especially hydrogen, it is extremely volatile. Phosphorus and potassium burn brilliantly if in contact with the solid substance. CS_2 is decomposed with a violent reaction. It acts as a strong oxidizing agent with ferrous and sulphurous solutions.

L. Wenghöffer, "*Action of Sulphuryl-Chloride and Ethyl-Sulphuric Chloride on Aniline.*" The author does not find the reactions of $SO_2Cl.OC_2H_5$ entirely analogous to those of $COCl.OC_2H_5$. With aniline, sulphanilic acid is produced:

$$C_6H_5NH_2+SO_2Cl.OC_2H_5=C_6H_4(NH_2)(SO_3H)+C_2H_5Cl.$$

Acetanilide yields a more complicated body:

$$_2C_6H_4.NH.C_2H_3O+SO_2Cl.OC_2H_5= \\ =C_2H_5Cl+H_2O+SO_2(NHC_6H_4C_2H_3O)_2.$$

By the action of sulphuryl chloride on acetanilide, and subsequent elimination of the acetyl group, a body was obtained with the formula $C_6H_4.NH.SO_2$.

B. Blakenhorn finds, in the course of experiments "*On the Action of Sulpho-cyanic Acid* in statu nascendi *on Alcohol,*" that a sulpho-allophanic ether is produced—

$$NH_2CS.NH.CS.OC_2H_5.$$

By heating with NH_3 at 100°, it is changed into sulpho-carbamide.

C. Hell and A. Waldbauer have obtained from the "*Action of Alcoholic Potash on Mono-brom-iso-butyric Acid,*" ethyl-oxy-iso-butyric acid—

$$(CH_3)_2C(OC_2H_5).COOH,$$

a colorless liquid, with ethereal odor, boiling at 180°, and

slightly heavier than water. The salts are very soluble and crystallize finely.

C. Hell and E. Medinger, "*On the Oxidation of the Acid $C_{11}H_{20}O_2$ in Crude Petroleum.*" Both by treatment with HNO_3 and potassium bichromate, it is oxidized into acetic acid, and a new acid, $C_9H_{16}O_2$, a nonylonic acid. The authors are of the opinion that the original acid contains no carboxyl group, on account of the decomposition.

A Naumann, "*On the Decomposition of Molten Potash Alum in Sealed Tubes at 100°.*" After melting, a gradual decomposition takes place, which consists of a separation of water of crystallization, and precipitation of the anhydrous compound. The free water causes then, in the liquid portion, the separation of a basic compound of alumina, potash, sulphuric acid, and water.

K. Zulkowsky, "*On the Composition of Corallin.*" The author's experiments lead to the conclusions that the commercial dye stuff known as corallin consists chiefly of the lustrous crystalline substance, rosolic acid, and a dull red resinous body, temporarily termed pseudo-rosolic acid, and yielding by oxidation a dark red compound. A body recently obtained by Liebermann and Schwarzer from phenol and salicylic aldehyd appears to be identical with pseudo-rosolic acid.

R. Nietzki, "*Decompositions of some Aniline Derivatives by passing through Heated Tubes.*" On passing dimethyl aniline through a glass tube, heated to a dull red-heat, large quantities of benzo-nitrile were formed. Acetanilide yielded, at a bright red-heat, diphenyl-carbamide.

L. Pfaundler, "*On the Temperature of the Vapors issuing from Boiling Solutions of Salts.*" The author seeks to explain the fact that the thermometer surrounded by these vapors always marks a lower temperature than that at which the solution boils, by the hypothesis that the vapors consist of molecules of various temperatures—some above and some below the temperature marked by the thermometer, and even of particles of water. When these come in contact with the surface of the thermometer the colder particles adhere, and as they are caused to evaporate by the collision with the more highly heated molecules, the passage into the gaseous state naturally causes a constant lowering of temperature about the bulb of the thermometer.

L. Loewenherz, in a communication "*On Fundamental Thermometric Experiments,*" states that a noticeable error in the height of the thermometer is to be observed when it is immersed in mercury, due to the external pressure on the bulb. A change, amounting in one instance to 0·3°, in the melting-point of ice, was also observed to ensue after thermometers had been kept for several days in boiling water.—*Chemical News.*

DYEING LEATHER.

By M. W. EITNER, Director of the Imperial Laboratory.

THE author recommends, for leather-dyeing, the aniline colors prepared by the Berlin Aniline Dye and Color Company, which are specially arranged to suit the requirements of this trade. The preparatory operations required present no novel features, it being merely requisite that the leather should be perfectly clean, those intended for light shades being of course washed for a much longer time than those destined to receive dark colors.

For the production of so-called "Russian red"—formerly obtained with the red woods, along with a solution of tin and the occasional addition of alum or of tartar—the "Juchtenrath" or "leather-red" is recommended. It is produced in three shades—G, light; G R, medium; and R, dark. The color required is simply dissolved in 100 parts of clean, soft, boiling water, condensed steam-water being very suitable. The solution thus obtained is left to settle for two or three hours, and the clear liquid is then taken in greater or less quantity, according to the size of the pair of skins to be treated, diluted with warm water, and is then ready for use. It is not desirable to use a concentrated bath at the outset. The first pair of skins is therefore dipped at the beginning in a very dilute bath. They are then taken through a second and a third, each stronger than the foregoing. The second pair of skins is dipped in the second of the baths already used, then in the third, and lastly in a new bath as strong as the third before it had been used. Thus each bath is used three times, and each pair of skins is passed through two old baths and one new one. In this manner the color is thoroughly used up, and an even shade is obtained on the skins, which, if entered at once in a strong dye-bath, would take the color irregularly and become cloudy. When dyed, the skins are plunged in pure cold water, rinsed, placed on the stretcher, and slightly oiled. If birch-oil is used, for the sake of the peculiar odor of Russian leather which it imparts, care must be taken that no free acid is present, as always happens if the oil has been sophisticated with wood-tar; it must be carefully neutralized with carbonate of soda. The dyed leather should be rapidly dried in a room specially fitted up, as the aniline colors can endure higher temperatures than shades obtained from the woods. For moistening the leather for the subsequent finishing operations, very dilute solutions of "G" may be used.

A fourth shade, GG, gives a yellower red. Another, "Red S," gives the cochineal shades, especially pink. In the use of this dye the bath must be made as hot as the leather can bear. An addition of saffron (? saf-flower, or saffranin) decoction, as in the treatment with cochineal dyes, enhances the brilliancy of the color.

Most yellow dyes derived from coal-tar produce dark spots on such portions of the grain-side of the leather as have been scratched or scraped. Certain colors, however, prepared by the Berlin Company are free from this defect. Phosphine-orange gives the "brightest and most intensely yellow of the yellowish brown shades, commonly termed almond-yellow." It requires 500 parts of water for solution, and must be boiled till no residue remains. The liquid is then ready for use at once without dilution. If a less fiery shade is wanted, treatment with a solution of bichromate of potash lessens the vividness of the dye.

For a gold-orange color, the Philadelphia yellow of the same company is recommended, dissolved in 300 parts of water.

A redder shade is produced by "Berlin brown G," which is well fitted for reddening the darker shades produced with the dye-woods.

A pure orange may be obtained with "corallin" dissolved in 150 parts of water. It must be dyed and afterwards dried as rapidly as possible, as it has a tendency to fade.

A "half-dark subdued blue" is produced with "marine blue" dissolved in 300 parts of water. The skins must *not* be previously passed through dilute sulphuric acid.

For a pure light blue, "water-blue B B" is taken; and for redder shades, "water-blue R."

Dark blues were formerly obtained by the use of a red dye-ware over a vatted ground. The result is better obtained by grounding in "water-blue R" and topping with "nigrosin" dissolved in 300 parts of boiling water. Nigrosin applied directly to leather dyes uneven shades.

"Methyl-green" is much used for topping skins which have been dyed green with extract of indigo and fustic. All sulphuric acid must first be carefully washed away.

"Methyl violet" can be successfully used even on the worst skins.

The "B" variety yields blue shades, and the "R" produces red shades. The color is dissolved in boiling water, but may be used cold.—*Chem. News.*

OXYGEN OF THE AIR.

By improved eudiometrical methods Regnault afterwards settled conclusively the fact of variations in the percentage of oxygen in the earth's atmosphere, and ascertained with accuracy the amount of the variation in the atmosphere of the same locality, and at different points on the earth's surface. The minimum amount for 100 analyses of the air at Paris was 20·913 per cent., and the maximum 20·999, giving as a mean the number 20·956. The lowest percentage in five analyses of the atmosphere of the ocean was 20·918, the highest 20·965. Of mountain air—in that of the summit of Mt. Pichinchi, which is higher than Mt. Blanc—the oxygen was 20·949 and 20·981 per cent. Of all places, Berlin had the distinction of an atmosphere with the lowest percentage of oxygen, 20·908. This does not appear surprising, when we call to mind the stinking waters of the River Spree flowing through the most crowded portion of the city, under the windows of the Academy of Music, and within a stone's throw of the Emperor's palace, the Opera House, the Royal Library, the Museum, and, worst of all, the famous University. To quote the language of Dr. Folsom, the Secretary of the Massachusetts Board of Health: "Berlin and Munich, the filthiest and most scientific of the German cities, deserve Traube's sarcasm of not being able to stop the cholera, even in winter—a more or less continuous epidemic, so to speak, having lasted since 1866; while in London and Paris, the cleanest of large cities, the last epidemic (in 1866) fell very lightly, and the death rates are one-third lower than in Munich and Berlin." The mean of all Regnault's analyses was 20·95 per cent., a number which should be remembered and quoted.—*Prof. A. R. Leeds.*

COOLING OF CANNON AND OTHER CASTINGS.

By JOHN S. ROBINSON, CANANDAIGUA, N. Y.

THIS relates to a process for the treatment of cannon, shafts, rollers, and other castings before removing them from flasks or moulds in which they are cast. Such treatment consisting in applying pulverized charcoal, or coal of any other kind, which will be ignited by the heat contained in the casting when such coal is reduced to the requisite degree of fineness. The material to be applied while the casting is at as high a degree of heat as is practicable, or as soon as the sand can be removed from its surface without causing a change of form, the object being to prevent the too rapid cooling of their surfaces and the consequent crystallization and weakening of the metal upon such surfaces.

It is a well-known fact that when heavy castings, such as ordnance, shafts, or rollers, are made in the usual way, their outer surfaces cool first, and frequently become quite solid in their character while the metal at their centers is still in a plastic or semi-liquid state, and hence it follows that when the central portion cools the tendency is to cause such portions to shrink away from the outer portions, thus causing upon the intermediate portions an undue strain, the result of which is an elongation and consequent weakening of the crystals of said intermediate portions.

By my improved process, the surfaces of such castings are kept at a high degree of heat until the radiation from the central parts has been such as to reduce the crystals thereof to nearly or quite the same state as those at or near the surface, thus allowing all parts to shrink or contract alike from that point, and thus insure a compression of the crystals at all parts instead of elongating or straining them.

SINGULAR CASE OF THE PRODUCTION OF HEAT.

By M. J. OLIVIER.

A SQUARE rod of steel, 80 centimeters in length and 15 millimeters square, is grasped firmly by both the hands of the operator, one of the hands being placed in the middle of the rod, and the other at one end. The free extremity is strongly pressed against an emery wheel revolving very rapidly. After a few minutes the extremity thus rubbed becomes strongly heated; the hand placed in the middle of the bar does not experience any feeling of heat, but the one at the other extremity is heated to such an extent that the operator is compelled to let go.—*Comptes Rendus.*

IMPREGNATED RAILROAD TIES.*

EXPERIMENTS have been made on the government railroads of Hanover, and on the Cologne and Minden Railroad on the durability of impregnated railroad ties, and it was found that of—

Hemlock ties impregnated with chloride of zinc, 30 per cent. has been renewed after having been in use for 21 years.

Beechwood ties impregnated with creosote, 46 per cent. had been renewed after having been used for 22 years.

Oak ties which had not been impregnated at all, 49 per cent. had been renewed after 17 years' use.

Oak ties which had been impregnated with chloride of zinc, only 20·7 per cent. had been renewed after 17 years' use.

All the experiments were conducted under the most favorable conditions, viz., on good, pure, and porous bedding.

Pieces of wood cut from impregnated ties in use at the expiration of the above periods, showed perfectly sound surfaces.

Observations made on the Northern Railroad of Austria (Kaiser Ferdinands-Nordbahn) have shown the following results:

Of oak ties which were impregnated, 74·48 per cent. had been renewed after 12 years' use.

Oak ties impregnated with chloride of zinc, 3·29 per cent. had been renewed after having been used for 7 years.

Oak ties impregnated with tar containing creosote, but 0·09 per cent. had been renewed after having been in use for 6 years.

Hemlock ties impregnated with chloride of zinc, 4·46 per cent. had been renewed at the end of 7 years.

Since 1869 the Northern Railroad of Austria use only oak ties which have been previously impregnated either with chloride of zinc or with tar containing creosote.

* Wochenschrift des Oesterreichischen Ingenieur und Architekten-Vereines, Wien.

ACTION OF CHLORO-CHROMIC ACID UPON ANTHRACENE.

By M. A. HALLER.

WISHING to utilize the action of chloro-chromic acid, at once oxidizing and chlorinizing, the author caused it to act upon anthracene so as to obtain bichlorated anthracene, which, on treatment with potassa, should yield alizarin; 10 grms. of anthracene were dissolved in glacial acetic acid, and treated with 30 grms. of chloro-chromic acid freed from chlorine by a current of CO_2. The green liquid was poured into distilled water; the yellowish precipitate collected on a filter, washed, dried, and partly sublimed in a retort, and partly dissolved in alcohol. Both the sublimate and the matter obtained on crystallization had the form of splendid needles, having all the properties of anthraquinon. They dissolved with a reddish yellow coloration in concentrated sulphuric acid. Water precipitates the bulk of the product from the solution. If melted with potassa they gave a violet mass, which on solution in water was partly decolorized, unaltered anthraquinon being precipitated. The potassic solution, acidulated with nitric acid, filtered, and treated with nitrate of silver, did not give a precipitate of chloride of silver. The product therefore, contained no chlorine, and was pure anthraquinon.

PHOTO-CHEMICAL PROCESSES IN THE RETINA.

PROF. A. GAMGEE lately gave in *Nature* an account of certain very remarkable discoveries made by Prof. Kühne, of Heidelberg, which added additional interest to the startling announcement contained in a recent communication made by Prof. Boll, of Rome, to the Berlin Academy, to wit, that the external layer of the retina is, during life, of a purple color, which disappears at death, but which is, during life, continually being bleached by the action of light.

By the most recent results obtained by Kühne on the "Vision Purple" and published by him in the *Centralblatt für die medicinischen Wissenschaften.* The purple color of the retina is now shown to depend upon the presence of a substance which can be dissolved and separated in the solid form. The only solvent of the vision-purple as yet known is bile, or a pure glyko-cholate. The filtered, clear solution of the vision-purple is of a beautiful carmine red, which when exposed to light rapidly assumes a chamois color, and then becomes colorless. As long as it is at all red, the solution absorbs all the rays of the spectrum, from yellowish-green to violet, allowing but little of the violet, but all the yellow, orange, and red rays to pass. Accordingly, bloodless retinæ spread out and placed in the spectrum between green and violet appear gray or black.

Kühne has exposed retinæ in different parts of a spectrum (obtained by allowing the sun's rays between eleven and one o'clock to fall through a slit 0·3 mm. wide upon a flint glass prism), in which Fraunhofer's lines were shown in great number and with great distinctness, and he has ascertained that in the yellowish green and green regions the vision-purple is bleached most rapidly; that action is less in the bluish green, blue, indigo, and violet; it is still perceptible in the orange and yellow, but not in the red or ultra-violet regions.

THE LIME LIGHT WITHOUT OXYGEN.

It is now upwards of nine years since we gave details of a French invention by M. Bourbouze, by which an artificial light was produced by a mixture of atmospheric air and common gas (as in the well known Bunsen burner) being allowed, when ignited, to impinge against a grating formed of fine platinum wire. The Bourbouze lamp was never much known, at least in this country, and it is now a thing of the past—so far, at any rate, as we have been able to ascertain.

Several years ago the great heat capable of being produced by a proper mixture of air and gas suggested the application of this mixture to lime as a means of rendering it luminous; and in 1869 we recorded the fact that Messrs. Darker, of Lambeth, London, Eng., had applied the principle of mixing air, instead of oxygen, with common gas, with a view to the production of the lime light. We are aware that they subsequently discontinued its use, owing to its not being so successful as they had anticipated.

With the foregoing, by way of introduction, we now proceed to describe a trial of a modified light of the kind referred to which was recently made by Mr. Woodbury in our presence. Mr. Woodbury's connection with the sciopticon, as co-patentee and as its introducer into this country, is known to our readers. Finding that photographers required a twofold advantage not afforded by the ordinary petroleum lamp of the sciopticon, and which is comprised in the two points—first a smaller flame, and secondly a purer light—finding, further, that a widespread objection exists against the making and storing of oxygen, Mr. Woodbury endeavored to ascertain whether by means of some modified burner the "lime light" could be obtained without the use of any oxygen other than that contained in atmospheric air. The advantages arising from heating the air supplied to a furnace are familiar to everyone who has heard of the hot-blast smelting furnace; so likewise has this advantage on a smaller scale been known to those who are familiar with the Fletcher blowpipe, and by a judicious arrangement of the latter, and applying it to the illumination of the sciopticon, the light was obtained which we shall now endeavor to describe.

The burner is one nearly similar to that recognized as the "blow-through" jet—a blowpipe passing up through a larger jet, from which issues common gas. This centre blowpipe is connected with a bag or reservoir containing atmospheric air; but it is so constructed that previous to its insertion in the larger or common gas pipe it winds, like a corkscrew, through the flame of a Bunsen burner placed underneath. But as this corkscrew surrounds the pipe through which the common gas is conveyed, it follows that both pipes are heated, and, in consequence, both the gas and the air are ejected from their respective orifices in an intensely heated condition. A lime cylinder, when subjected to the action of this blowpipe, becomes incandescent and highly luminous.

When two sciopticons were tested side by side, one of them being fitted with the well known petroleum lamp having a double wick, and the other with a burner such as that here described, the two disks presented well marked peculiarities. Previous to the lime light disk being displayed, that from the petroleum-burning sciopticon had been carefully observed, and it was considered to be as bright and

luminous a disk as it was possible to obtain from such a source of light. But no sooner was a second disk from the lime burner projected alongside the first than the former immediately assumed, by contrast, a yellow hue. Not only was the lime light disk of a purer color, but it was also more luminous, taking a place between the ordinary light of the sciopticon and the oxycalcium light.

We should not like any reader to receive the impression that the hot atmospheric-air light is as good as the ordinary oxyhydrogen lime light, for such is not the case; but we affirm most positively that it is superior in purity and intensity to any oil lamp that we have hitherto seen applied to the lantern. We shall give a more detailed description of the mechanism of this burner shortly; in the meantime we are enabled to state that, while the light is sufficiently good for being used in the production of enlargements, the burner is so constructed as to be capable of being used with oxygen as well as with atmospheric air, in which case it is merely an oxyhydrogen burner of the "safety" description. From the foregoing it will be seen that no claim whatever is made for novelty of principle, but merely for such mechanical adaptations as permit this light to be applied successfully for lantern purposes.—*British Journal of Photography.*

TRANSFER OF NEGATIVE FILMS TO PAPER.

THE process of transferring the film from glass by means of gelatin paper, which has frequently been discussed in this journal, led me to try albumenized paper for the same purpose. The plan I found to answer excellently, whether in the case of old or new negatives.

When the negative is not varnished, it only requires to have water poured over it, and then albumenized paper whose surface has been thoroughly moistened with a wet sponge is laid upon the plate, and pressed in contact with a dry handkerchief. The albumenized paper will then bring away with it a film from the glass. Care need only be taken that when the wet albumenized sheet is placed upon the glass, no air-bubbles get underneath.

In stripping the paper subsequently from the glass, you begin at one corner of the image, where the collodion goes right up to the margin of the glass: and when necessary the border is lifted by means of a penknife or a steel pen. A preliminary dipping of the negative in a mixture of one hundred parts of water and two parts of hydrochloric acid loosens the film, but before the paper is applied the plate must be thoroughly washed, so that no trace of acid remains adherent to the film.

When the negative is varnished, the varnish is removed by placing the plate in a bath of

Caustic potash	5	grammes.
Water	60	"
Spirits of wine	250	"

The plate is permitted to remain in this bath for the space of a minute, and is then taken out, washed, and treated as above.

The stripping of the film by means of albumenized paper is a method suited for artists, amateurs, and others, and less for professional photographers, for whose work a paper basis is at times inconvenient. The former prefer to use gelatin paper, for they can then at any time re-transfer the film to glass in either sense.

The way to strip a film by the aid of gelatin transfer paper, in an easy and certain manner, Mr. Woodbury has already described, although that gentleman does not specify the particular kind of transfer paper he employs. But you may proceed as follows: Eighteen grammes of gelatin—Nelson's Patent Opaque Gelatin is the most suitable—are permitted to soak in cold water for some hours. The water is then poured off, and the gelatin permitted to dissolve in a water bath; gradually one hundred grammes of spirits of wine are added, the solution being stirred the while.

This solution in a warm state is applied by means of a soft brush to a piece of thin paper which is somewhat larger than the negative. The negative is well moistened with warm water, also by the aid of a soft brush, and the paper laid upon the film. Air bubbles must be avoided.

When the paper has become perfectly dry, it is moistened with a sponge, and a corner thereof carefully lifted; then the whole is gently drawn from the glass. The paper may, when dry again, be rendered transparent, or the film may be again transferred to glass for printing purposes. Both methods are suitable for transferring films which require to be stored, and may not be wanted for printing again for a while.—*Photographisches Archiv.*

ANCIENT AND EXTINCT BRITISH QUADRUPEDS.

By A. LEITH ADAMS, M.D., F.R.S.

ANY account of the quadrupeds which frequented the British Islands in bygone ages and before historic time would be imperfect without a brief allusion to the physical conditions of the country during the period of their existence. My observations on that head, however, will be confined to the vast epoch which has elapsed since the close of what is known as the glacial period, when Europe was emerging from the white sheet which for unreckoned ages had clad it, from the Pole to the Mediterranean, in ice and snow. The proofs of this curious episode in the history of the earth are as clear as is the existence of glaciers at the present day. It is, moreover, evident that the cold period came on suddenly, and, as regards the British Islands, at a time when the physical aspect of the country—at least, as regards the main features of the landscape—did not materially differ from what is now observed. The land was then inhabited by quadrupeds, some of which were identical with species now living, although many afterwards became extinct, and did not reappear. This has been named the pre-glacial period, when our climate was perhaps somewhat milder than it is at present. During the subsequent glacial epoch the whole of the British Islands, including portions since submerged, were clothed in an eternal winter mantle, partly snow and partly in the form of glaciers, which moved down from the high to the low lands, carrying with them rocks and *débris* of all kinds to form fresh deposits.

The remains of the animals in question have been preserved chiefly in caves or in river deposits. The limestone caverns, in which they are found, usually present the following appearances: On the floor there is a bed of calcareous drippings hardened into a substance known as stalagmite. Under the latter may be seen successive layers of clay and stalagmite of various thicknesses. Sometimes the osseous remains are found on the floor of the rock simply embedded in the stalagmite. The various levels formed by an alteration of cave-earth or clay and drippings may represent various stages in the history of a cave. For instance, on the surface flint tools, fashioned by man, together with bones of the Red Deer and Oxen, may be found; in the second layer may be discovered the remains of herbivorous quadrupeds and of Lions and Elephants, the larger bones showing evident traces of having been gnawed by predaceous animals. Under these conditions, it may be surmised that the cave was originally a den of carnivorous animals, which had dragged in the bones of their prey, until the surface, getting gradually covered over by stalagmitic drippings, became eventually the resort of man. Of course the absence of traces of his presence is no proof that he may not have been contemporary with the Lions in the second deposit; at the same time, we are not justified in admitting his presence unless we find the bones of domestic animals, flint tools, or other relics of man mingled in the same stratum. As to the age of these two deposits, they may or may not represent long periods; much depends on the rapidity or otherwise of the influx of the cave-earth, either through rock-fissures or by the aid of streams, which convey large quantities of soil into underground caverns; while the extent of dripping of the lime-water from the roof and sides, and its hardening, depend entirely on circumstances; for a cave may be filled to the top in a comparatively short time, or its filling may be the work of ages. In either case some covering of the bones must take place before they have time to decay, as they otherwise would do if left uncovered. It is wonderful how little stalagmite is required to preserve a bone; a mere crust, not the thickness of a shilling, will often suffice to preserve the thigh-bone of an Elephant. It is now generally supposed that many of the rivers of our southern and eastern coasts are but the head-waters of what were once much larger rivers before the severance of the islands from the mainland of Europe. The Thames is thought to have been one of the tributaries of the Rhine; and, as will be noticed in the sequel, it is seldom that oyster-dredging is prosecuted with vigor on the coasts of Norfolk and Suffolk without quantities of bones of extinct quadrupeds being brought to the surface. When the separation in question took place is not altogether clear; that England and Europe were united, however, at the close of the glacial epoch seems pretty certain, else how could such animals as the Elephant and the Lion have reached the British Islands? The probability is that there was a highway at the Straits of Dover, which may have disappeared before the Lions and Elephants died out on British soil.

With the thaw of the glacial period the rivers doubtless became, then and along afterwards, subject to constant inundations, which covered large tracts of country, and formed deposits of sand, loam, and clay, in which the animal remains are now found. London, for example, is built on deposits of the ancient Thames; and in many other situations where insignificant streams now exist, the banks are made up of vast beds of *débris* stretching inland, and containing the bones of both extinct and living animals. Again, deep in the brick-earths of the Thames Valley, at Clacton, Ilford, Grays (Essex), and Crayford, remains representing herds of giant Oxen, Deer, Elephants, Rhinoceroses, etc., have been discovered from time to time, indicating that they had probably been drowned and carried down by inundations of the Thames. In the nature of the animal remains, there is a general accord with those of river-bottoms and of the caves, thus showing that they were of the same geological period. But in the brick-earths, or lowermost strata of rivers, it sometimes happens that remains of animals are found distinct from any other species found in the upper beds and in the caves; in consequence, it has been surmised that the brick-earths may have been deposited during pre-glacial times, and therefore contain the animals of that epoch. Some idea of the animals which frequented Wales, South and Southwestern England, the Thames Valley, Yorkshire, and the South of Ireland may be gathered from the following:

In several caverns in Glamorganshire remains of man have been found, associated with bones of the Rhinoceros, Spotted Hyæna, Badger, Ermine (or Stoat), Polecat, Wolf, Fox, Otter, Grisly Bear, Brown Bear and Great Cave Bear, Reindeer, Roebuck, Red Deer, Bison, Urus (or Giant Ox), Hippopotamus, Pig, Horse, two species of Elephants, Hare, Rabbit, Water Rat, Cat, Lion, and Great-horned Deer. In the Devonshire caves, the same animals, with the addition of the Sabre-toothed Lion and the Lemming. In the brick-earths and deposits of the Thames an exact repetition of the first have been found, with the addition of the Beaver. The celebrated cavern of Kirkdale was a den of Hyænas, where nearly all the animals of the other caves were found, thus showing a very general distribution throughout the country. The only Irish cave or river deposit at all fruitful was the cavern of Shandon, in the county of Waterford, where remains of the Mammoth, Elephant, Horse, Reindeer, Red Deer, Grisly Bear, Wolf, Fox and Hare were found associated. Scotland, not possessing many limestone caverns, and the Highlands being of granite formations, together possibly with the effects of a rigorous climate during the period when the quadrupeds in question were living in England, may account for the absence of remains of any save the Wolf, Mammoth and Reindeer, although others may remain to be discovered.

I now propose to note a few of the more interesting details which geologists have brought to light concerning the various species of animals which formerly inhabited the British Islands, but which are now either extinct or only exist in a few localities and in greatly diminished numbers.

The Brown Bear is one of the few extinct British beasts which survived up to the historical period, and, although it had disappeared probably for centuries beforehand in England, we have it on excellent authority that it was common on the Scotch Highlands as late as the middle of the eleventh century.* The date of its existence in Ireland is not recorded;† indeed, as will be presently shown, there are doubts if the Brown Bear (*Ursus arctos*) was a native of that island. It was, however, generally distributed over Central and Northern Europe, and it still lingers on the Eastern Alps and in Russia, and is spread over Northern Asia, and probably also the boreal regions of North America. In the color of the fur, and also in size, in different countries it is subject to considerable variation, so that naturalists considered the individuals from Norway, Syria, the Himalayas, and Siberia as so many distinct species. If the mere external coloration, however, and a few other minor points be disregarded, it will be found that the bony skeletons of all agree in characters which, as compared with other bears, at once place them in the same category with the typical Brown Bear (*U. Arctos*). In regard to size, the skulls and bones dug up in the fens, peat-bogs, and superficial deposits in England, certainly belonged to large individuals, but not larger than many now inhabiting different parts of Europe and Asia.

Not only does historical evidence, accompanied by the discovery of its bones in peat and alluvium, point to the existence of the Brown Bear in unrecorded times, but we find its bones, associated with those of at all events very much larger species, in the caverns and deep soils of England; moreover, seeing that the remains in either case represent very old individuals, and that the teeth and bones differ in many respects, there is good cause to believe in the former existence in Great Britain of at least two species of Bear.

The Great Bear of the caverns and the Brown Bear were therefore contemporaneous. As to the former, on arranging and comparing exuviæ collected in Great Britain and on the Continent with bones of living species, it has been found that they admit of division into three, or at least two, distinct forms. One agrees with the skeleton of the Grisly Bear, now chiefly found in the Rocky Mountains and western prairies; the other (*Ursus spelæus*) and perhaps a third (*U. priscus*) have no living representatives, and may therefore be considered as having become extinct in Great Britain long before the historical period. But the Grisly Bear, as far as is known, seems to have disappeared likewise about the same time.

The *Ursus priscus* was the giant of all. Although not rare in England, it appears to have been very common in Southern France and in the Pyrenees, judging from the quantities of bones discovered in the caves and soils. It would appear that, irrespective of larger dimensions, this Great Cave Bear was distinct from the Grisly, or else an unusual variation in regard to bulk and certain osteological characters obtained in the Grisly Bear of ancient Britain. Compared individually, the Brown, Grisly and Cave Bears stood in much the same relative height as the Shetland pony, Galloway, and dray horse.

The geographical distribution of these bears over the British Isles, so far as is known, seems to indicate that the largest form was restricted to England, and that the Grisly was also common in Ireland, where no certain remains of the Brown Bear have been yet discovered.

The Cave Bear no doubt was the first to disappear, followed by the Grisly, whilst the Brown Bear survived to within historical times. All were contemporaneous here long after the separation of Great Britain from the Continent, and gradually died off, it may be from failure of food or through human agency. Looking to the habits and food of living species, it is apparent that the Bear would survive the Lion, for the reason that it is not entirely dependent on flesh for its subsistence, but will eat vegetable food—indeed, many species prefer it to animal food; consequently the Lion may have died of starvation in Great Britain when the Deer and other prey became very scarce.* No doubt failure of food has brought about the extinction of many species, and in the case of the British Islands, even supposing man had not appeared on the scene, the severance from the Continent must have initiated a struggle for existence among the larger quadrupeds, of which the fittest only would survive. The Great Cave Bear and the Grisly, not to mention the Lion and Hyæna, must have been formidable enemies to the deer and wild oxen; indeed, the probabilities are that none of the former survived long after the separation from the mainland.

That man played a considerable part in exterminating the bear tribe is proved by the arrows, spears, and hatchets of stone which have been discovered in several caverns† either overlying the remains in question or associated with them. But, although man contributed to the extinction of many species, it is probable that these wild beasts enjoyed a long freedom before he appeared on the scene. How the thick hides were pierced by arrow or spear-points made of stone, and how man with such weapons could have held his own against powerful and ferocious bears and lions, seems a mystery when we think of the ferocity of the degenerate descendants of these animals. It is, moreover, a curious circumstance not easily explained that, whilst the tiger and lion are daily destroying human beings, we find no indications of man among the gnawed bones so plentifully distributed throughout the ancient caverns and dens of the post-glacial epoch. The only explanation would seem to be that the larger carnivorous quadrupeds found ample subsistence among the lower animals during the cave period without preying on the lords of creation.

The Glutton, now a native of the Arctic Regions of the Old and New Worlds, was contemporary with the Bears, and sought its fortunes on British soil. Its bones have been discovered in caverns and deep soils in England, but the date of its extinction is so far shrouded in obscurity.

The Badger is the sole remaining representative of the Bear family which still lingers in the British Islands. Like the Glutton, it existed with the Bears, but was not so plentiful, if we may judge from the few bones which have hitherto been discovered.

The Ermine, Polecat, Beech Marten and Otter can be traced back to the days when the large carnivores and elephantine quadrupeds lived in our islands; and it would appear that, in point of size, individuals of the ancient race did not greatly surpass their modern representatives. It seems probable, moreover, that in all cases where quadrupeds, from early epochs, have remained unchanged in point of size, although confined within narrower geographical limits, they have continued to enjoy abundance of their natural food. At the same time, it is the fact that several animals, as the Bear and Elephant, present to a greater extent individual variations in size, according to the favorable or inimical conditions under which they have happened to be placed. These are points of great importance to the naturalist, especially when attempting to trace back the history of extinct animals by a comparison of their remains with those of living species.

The British Lion is no myth. Two species of the genius *Leo* existed in England long after the glacial epoch. In one of these the canine teeth, so conspicuous in dogs and cats, were enormously developed; and their sharpness and curved form has suggested for the animal the name by which it is known, the Sabre-toothed Lion. Strange to say, the only portions of its anatomy hitherto discovered in this country (in Kent's Cavern) have been some of these very teeth; but on the European continent, as well as in the Himalayas, skulls have been found, as well as canine teeth, the latter varying in length from six to eight inches. If we may judge of the proportions of this beast from the size of its teeth, it must indeed have been a monster. It was a contemporary of the extinct bears and larger herbivorous quadrupeds, but

* Pennant says it was a native of Scotland in 1057.

† No tradition has yet been found with reference to its Irish residence, although the name *math-gamhuin* (calf of the plains) is supposed by many authorities to refer to the Bear. St. Donatus, who died A. D. 840, asserts it was not in the island in his time.—*A. L. A.* [The skulls of Bears referred to by Dr. Ball (Trans. Roy. Irish Acad., 1849) as having been found in Ireland, are now considered to have belonged to the Grisly Bear.—ED.]

* But the wild deer have outlived the lion, and survive to the present day. The wild ox was more probably the lion's prey.—ED.

† Amongst others may be mentioned Kent's Cavern; Brixham Cave, Devonshire; Long Cave, near Gower; and Wokey Hole, Cheddar, Somersetshire.—ED.

could never have been numerous. Indeed, had it been as common as the existing African and Asiatic Lion is in many inhabited parts of these continents at the present day, neither primæval nor savage man could have held his ground against it. The other species of British Lion was both taller and stouter, and had broader paws than its modern representative, otherwise the latter would be regarded as a degenerate descendant of the older race.

There is no sufficient reason for believing that such animals as the Lion, Elephant, or Rhinoceros did not frequent cold regions. The short-haired Tiger of Bengal is replaced by a woolly-haired Tiger in northern China; and in the frozen soil of Siberia discoveries of entire carcases of Elephants and Rhinoceroses clad in dense fur coats prove the exception to the general rule with reference to the covering of their living representatives. The fossil Lion, like the large fossil Bear and Hyæna, was long considered to be distinct from living species, but recent discoveries and comparisons have indicated the closest relationship between the living and the dead. Vestiges of the Lion have been discovered in nearly twenty British caverns, as well as in the deposits of rivers; associated in the former case with remains of Bears, Elephants, Rhinoceroses and other herbivorous animals, as well as with Hyænas. In fact, the Lion was one of the earliest sojourners in the land after the glacial period had commenced to decline.

A Leopard or Panther, apparently not larger than existing species, also roamed over England in company with the preceding. If its numbers can be at all estimated from the remains which have been discovered in caverns and river deposits, it is clear that this feline animal was not common; the likelihood may have been that it had no chance with its more formidable rivals just mentioned, who monopolized more or less their common prey.

The Lynx, which is still resident in many parts of the Continent, was also a native of pre-historic England, but hitherto its remains have only been discovered in a single locality.

The Wild Cat, although now very local in its distribution, still lingers on the scene where its progenitors lived with the Lion, Bear, Wolf, and other carnivorous animals. On comparing the skeleton of the ancient British Wild Cat with that of a recent individual, no difference is observable, for the reason probably that birds and rabbits, its natural prey, have abundantly supplied its necessities; it has, however, been gradually destroyed, or driven back to a few remaining strongholds, by civilized man.

The Hyæna, which frequented Great Britain in pre-historic times, and contemporaneously with the extinct bears, was of larger dimensions than any species now living, although it is now generally regarded as the progenitor of the Spotted Hyæna.

The Spotted Hyæna, as we may call it, was at one time very common in England, but does not seem to have existed either in Ireland or the Highlands of Scotland. A graphic description of one of its numerous dens is given by Dr. Buckland,* who, in referring to the contents of Kirkdale Cave, Yorkshire, likens the floor to a dog-kennel, where gnawed fragments of the bones of Elephants, Rhinoceroses, Bears, Lions, and herbivorous quadrupeds were strewn about among the remains of no less than three hundred Hyænas, the droppings (coprolites) of which were also met with in profusion. This ancient den must have been used by them for a very long period, and, considering that the remains of no less than twenty different species of animals were discovered there, it may be surmised that, at all events, there was a great variety of quadrupeds in the woods and wolds of Yorkshire in those days. Although the Hyæna does not refuse flesh in a fresh state, it prefers a putrid carcase; and its powerful jaws and strong conical teeth, surrounded at the base of the crown by a belt of enamel, are eminently adapted for crunching bones, for which it has a predilection. It is a sneaking and cowardly animal, and on any show of resistance by its intended victim will hesitate and even retire. Remains of the Spotted Hyæna have been found in upwards of thirty different caverns in England, and generally in such abundance, as compared with other bones, as to show that it was plentifully distributed over the low lands and forests of ancient Britain. The reason for its absence from Ireland, as before noticed, is not clear; unless, perhaps, there was no direct highway between the two islands, as there was between England and the European continent. Moreover, it may be that the country was not sufficiently inviting, although large game, such as the Reindeer and the so-called Irish Elk, abounded. At all events, not a trace of the Hyæna has as yet been found in Ireland, and there are no authentic accounts of any such remains from Scotland, which, as far as the northern parts were concerned, was then doubtless more or less clad in snow and ice. Again the habits of the Spotted Hyæna, as now known, show that it is not a beast of the mountains, but of the plains.

All the quadrupeds which have lingered on in Great Britain to within historical times were evidently sooner exterminated in England than elsewhere. The Wolf furnishes an instance. It was quite a scourge in various parts of Ireland and Scotland during the seventeenth century, especially in the former country, where a breed of wolf dogs was carefully preserved.† This race of dogs is now also extinct. It resembled the Scotch Deerhound, but the skull was more wolf-like, so that there is now some difficulty in distinguishing the one from the other. Traces of old circular intrenchments, into which cattle, sheep, and goats were driven for protection from wolves, are still met with in abundance in many parts of Ireland, especially in the southern counties. Unlike other extinct British beasts, the Wolf apparently has not deteriorated in size, for the fossil bones which have been discovered are not larger, nor in any way to be distinguished from those of European Wolves of the present day.

When Hyænas and Lions roamed over England, the Wolf was apparently the only large carnivore in Ireland. From this circumstance it has been argued that Ireland was detached from Europe before England and Scotland; or, what may have been more likely, that the physical conditions of the former were not suited to the habits of the animal. Indeed, the apparent anomaly might be explained by comparisons with recent species. Thus, the Brown Wolf, although met with along the lowland valleys of the European and the Asiatic Alps, is not found on the high mountains; and on various parts of the Himalayas, Bears, Deer, Ibex, etc., may abound on one range and not on the adjoining one, although apparently equally inviting. To the naturalist who traces back the history of animals into the unrecorded past it is important to know the habits and haunts of living species, and especially their general and particular distribution, inasmuch as the finding of fossil remains in abundance in one situation, and the absence of such remains in another, might lead to the belief that the localities represent two different stages in the earth's history. Moreover, many wild animals repel other species from their haunts. It is said that few of the large quadrupeds frequent districts resorted to by the African Elephant, in consequence of his nocturnal habits and the disturbance he creates in his wanderings; and the Ibex and Great-horned Goat of the Himalayas monopolize whole ranges, and maintain the sovereignty against all other ruminants.

* Bridgewater Treatise.

† The last Wolf killed in Ireland was in county Kerry, in A.D. 1710. It was common in Connaught, according to O'Flaherty, in 1700. In 1641 and 1658 Wolves were very troublesome, and a council order by Cromwell, dated at Kilkenny, prohibits the exportation of wolf dogs.—*A. L. A.*

The Wolf must have fed sumptuously in Ireland among the herds of Reindeer and the Great horned deer which abounded in that country, seeing that it had no rival, such as the Lion, Panther, or Hyæna, to dispute its rights; indeed, naturalists have surmised that the finding of the skeletons of herds of the latter in the mud of ancient lakes in Ireland indicates that the animals had been driven into the mire by packs of Wolves. We can well imagine the enactment of such a scene as the "Race for Life," so artistically pourtrayed in Mr. Joseph Wolf's 'Wild Animals,' on many a tarn of ancient Ireland, before the formation of the peat.

The Arctic Fox has been but lately added to the ancient British fauna, whilst the Common Fox, as one of a few privileged species, has contrived to maintain its footing in the country to the present day.

The Deer tribe was represented in our islands from the glacial period up to the recent times by the gigantic animal known as the Irish Elk, which, with the Moose or Elk, and Reindeer, disappeared from this country before the historical epoch, whilst their contemporaries, the Red Deer and Roe, have, through careful protection, survived them.

The Great-horned, or Gigantic Deer, was unquestionably one of the most magnificent quadrupeds that ever trod the face of our planet. A full-grown stag, standing erect, measured from ten feet to twelve feet from the ground to the summit of the antlers, the spread of which covered over ten feet; with such a span, it has often been a matter of wonder how the animal could proceed through the forest, unless, as the Red Deer often does, it constantly dipped the antlers, which in case of pursuit would greatly impede its progress. Hence the supposition is that it fed more in the open, along the bare hill-sides and by the margins of lakes. The first entire skeleton was discovered in the Isle of Man about 1825; subsequently larger and more perfect skeletons were found in Ireland, and, almost without exception, in the shell marl and clay underlying the bogs. We believe we are correct in stating that no remains of the Great-horned Deer have yet been found in the peat, which shows that the animal must have died out before the moss and other water plants commenced to form on the lakes. Notwithstanding the discovery of several thousand heads and bones of this Deer, they afford no indication that man was contemporary with it, and old Irish literature has been ransacked in vain for evidence on this point.

It was, however, contemporary with the Reindeer in England and Ireland, where remains of the two have been found associated either through chance or choice; and there is no doubt that the animal was at one time extremely common in the sister isle—so plentiful, indeed, that there are few peat bogs which have not produced exuviæ.

During the summer of 1875 no less than thirty skeletons huddled together were exhumed from underlying clay in the bog of Killegar, among the Dublin mountains, whilst in the same situation (both instances occurring in an area of not a hundred yards by twenty) in 1847 as many as thirty more heads of this Stag were found. However the deer perished—whether by getting mired when crossing the lake, or when feeding along the margin, or on being driven there by wolves—it is clear that entire herds were destroyed at the same time. The above is only one of many such instances. Amongst the heads found at Killegar in 1847 were two with interlocked antlers. Another and similar instance is recorded from a bog near Limerick,* so that it would seem that many deer lost their lives in mortal encounter along the sides of lakes.

The objection to this deer being called an Elk is the obvious dissimilarity in the form of the antler in the true Elk and so-called Irish Elk. The former had neither brow nor bez antler†; for a long time they were confounded, although, when the difference is pointed out, a glance is sufficient to distinguish them. The weight of the heaviest skull and horns of the Elk seldom exceed 55 lbs., and the extreme breadth across the latter is about 70 inches; whereas many dried specimens of its Irish congener weigh upwards of 90 lbs., and give a horizontal measurement of antlers of as much as 120 inches. The great ugly skull and short neck of the Elk, allowing the antlers to be easily thrown back on the withers, contrast with the small handsome head and long serpentine but powerful neck of the Great-horned Deer. The delicately formed limbs of the latter are unlike the large-boned extremities of the former; in fact, the entire aspect of the latter shows a rare combination of great strength and agility, not equalled in any living species of the family. Although no remains of this deer have been found in conjunction with those of other wild denizens of Ireland, excepting the Reindeer, the probability is that, like the latter, it was a contemporary of the Bear, Horse, and Mammoth. Its remains have turned up in about twelve different English caverns, and in various river deposits, associated in several instances with bones of the large Carnivora and other extinct quadrupeds, showing that it had a place in the ancient British fauna at an early period. Nowhere, however, does it seem to have been so plentiful as in Ireland. This has been accounted for, as before observed, by the paucity of carnivorous quadrupeds, and of such bloodthirsty enemies as the Lion, the Hyæna, and the Bear. In all probability the sharp-pointed antlers ably resisted the attacks of the packs of Wolves which doubtless hung on the flanks and rear of the herd to pull down the young and weakly.

A few years ago, under a bog in county Longford, several bones of the Giant Deer were discovered, in which were deep incisions, as if made by man; indeed, had there not been a ready explanation to the contrary, the appearances were almost conclusive in regard to the artificial nature of the indentations, which resembled the clean cuts made by an ax or hunting-knife. On the shaft of a thigh-bone, close beside it, and fitting into the incision, was the sharp, angular side of the shaft of a tibia, or leg-bone, of the same animal. The quaking or constant up-and-down movement of the mud of the bog for ages, under the successive influences of heat and cold, had caused the tibia to cut deeply into the thigh-bone, and so imitate the appearance of a clean incision by some sharp-edged implement. But, although there are no records of the contemporaneous existence of this Deer and man in Ireland, there are caverns, such as Brixham, Kent's Cavern, and Wokey Hole in Somersetshire, where stone implements of man have been found in proximity with its remains. Many of its bones found in Irish bogs contain marrow, and blaze freely when burned. The small value put on them in times past may be gathered from the fact that the intelligence of the Battle of Waterloo was celebrated in a village in county Antrim by a bonfire of the bones of this animal, while its great horns were often used to form garden fences.

* Oldham, Journal Geological Society of Ireland, vol. iii., p. 252.

† Several attempts at imposition have been practised in Ireland by importing horns of the Moose, and painting them red to give a semblance of antiquity. The head of the male Gigantic Deer is in great request among dealers, and in a recent instance as much as £25 was given for a skull and horns of by no means a large individual.—*A. L. A.*

The freshness of the remains, allowing for the excellent preserving influence of the marl, would seem to indicate that the decease of the Giant Deer is of more recent date than that of many of its congeners, and yet, so far as Ireland is concerned, man does not seem to have contributed in any way towards its extermination.

(To be continued.)

ZOOLOGY.

Protective Mimicry in Bats.—Dr. Archer has noticed that a Brazilian bat (*Rhynchonycteris naso*) presents an example of protective mimicry, inasmuch as, during repose, it hangs from the branches of trees with its wings extended, so as easily to escape notice among the leaves. Dr. Dobson, in a letter to "Nature" (February 22), in reply to that of Dr. Archer, indicates other instances of mimicry in the same order of mammals. Thus *Kerivoula picta*, *Vespertilio formosus* and *V. Welwitschii*, although differing in several respects, and inhabiting widely separated regions, exhibit a very similar coloration, the fur of the body being of some shade of orange-brown, while the wings are variegated with orange and black. The grounds for regarding this coloration as an instance of protective mimicry may be seen from the following quotation from a paper by Mr. Swinhoe. He says: "A species of *Kerivoula* allied to *K. picta* and *K. formosa*, was brought to me by a native. The body of this bat was of an orange-brown; but the wings were painted with orange-yellow and black. It was caught, suspended head downwards, on a cluster of the round fruit of the Longan tree (*Nephelium longanum*). Now, this tree is an evergreen; and all the year through some portion of its foliage is undergoing decay, and the particular leaves being, in such a stage, partially orange and black. This bat can, therefore, at all seasons, suspend from its branches, and elude its enemies by its resemblance to the leaf of the tree. It was in August when this specimen was brought to me. It had at that season found the fruit ripe and reddish-yellow, and had tried to escape observation in the semblance of its own tints to those of the fruit." With regard to the great Frugivorous bats of the genus *Pteropus*, which measure nearly a foot long, with an expanse of wing between four and five feet, Dr. Dobson says: "Any one who has seen a colony of these bats suspended from the branches of a banyan tree, or from a silk cotton tree (*Eriodendron orientale*), must have been struck with their resemblance to large ripe fruits, and this is especially noticeable when they hang in clusters from the leaf-stalks of the cocoanut palm, where they may be easily mistaken for a bunch of ripe cocoanuts. Hanging close together, each with his head bent forward on the chest, his body wrapped up in the ample folds of the large wings, and the back turned outwards, the brightly colored head and neck is presented to view, and resembles the extremity of a ripe cocoanut, with which this animal also closely corresponds in size." Of the smaller Frugivorous bats of the genera *Cynopterus* and *Macroglossus*, which feed on the fruit of guavas, plantains, and mangoes, Dr. Dobson remarks that they "resemble these fruits closely in the yellow color of their fur and in their size, so that it is very difficult to detect one of these bats when suspended among the leaves of any of these trees," but he is not prepared to maintain that these are examples of "protective mimicry."

The Nest of the Aye-Aye.—According to MM. A. Milne-Edwards and Grandidier, that curious quadrumanous mammal the Aye-Aye (*Chiromys madagascariensis*) constructs a large globular nest. A specimen procured by M. Soumagne, honorary French consul in Madagascar, and sent by him to Paris, is described as being made with much care and art at the fork of several branches of a large Dicotyledonous tree. Its outer surface is formed of large rolled-up leaves of the *Ravinala* (or travelers' tree), serving as an impermeable covering for the interior, which contains an accumulation of small twigs and leaves. The narrow aperture is placed on one side. In this respect, as MM. Milne-Edwards and Grandidier remark, the Aye-Aye resembles the lower members of the order Lemurina (such as *Lepilemur*, *Chirogaleus*, and especially *Microcebus*), which bring up their young either in holes of trees or in true nests. The nest of *Microcebus myoxinus* is described as resembling, on a small scale, that of a crow, being composed of small twigs interlaced, with a depression lined with hairs in the center, in which the young repose.—*Comptes Rendus, January* 22, 1877.

The Nest of the Gourami.—M. Carbonnier has studied and described the habits of several species of fishes belonging to the curious group of the Labyrinthici, the "Pharyngiens labyrinthiformes" of Cuvier, so called from the singular structure of their pharyngeal bones, which constitute on each side a labyrinthic cavity for the reception of water, serving to moisten the gills when the fish is out of its native element. The Climbing Perch (*Anabas scandens*) of India is perhaps the most generally known species of this group, but the most important one is the Gourami (*Osphromenus olfax*), an inhabitant of the fresh waters of China and India, which grows to a large size, and is highly esteemed for the excellence of its flesh. The history of its nidification, as told by M. Carbonnier, is very curious. As in the case of most, if not all, nest-building fishes, the labor falls to the lot of the male. M. Carbonnier placed his gouramis in an aquarium containing about 48 gallons of water, which he kept at a temperature of 77° Fahr. In a few days the bodies of the males displayed brilliant colors and they began to pursue each other, and struggled furiously for the regards of the females. Having selected the finest male, M. Carbonnier left him in the aquarium with a female into whose good graces he seemed particularly anxious to insinuate himself. He soon commenced in one of the corners of the aquarium the formation of a frothy nest, which in a few hours was 6 or 7 inches in diameter, and 4 or 5 inches high. He then rose to the surface of the water, and drawing in a supply of air, gradually emitted it in the form of bubbles, englobed by the mucous secretion of the mouth; these bubbles he collected and carried into his nest. The nest being completed, the male watched by it patiently, and whenever the female approached he displayed his brilliant colors, until at last he seized her and caused her to perform a first spawning, and these operations were repeated until all the eggs were laid. In order to raise these into the floating nest, the male now

adopted a singular device. Rising to the surface, he took in an abundant supply of air, and then, descending, he placed himself well below the eggs, and suddenly, by a violent contraction of the muscles of the mouth and pharynx, drove the air contained in them out through the branchial apertures, from which it issued so divided by passing among the lamellæ and fringes of the gills, that it formed two jets of a regular gaseous dust which enveloped the eggs and carried them towards the surface. After the operation the male gourami himself looked as if he had been sprinkled with thousands of minute pearls. The number of eggs produced was estimated by M. Carbonnier at between two and three thousand, but only about six hundred of them hatched. For three days the young fishes resemble globular tadpoles, but within six days after hatching their development is completed. Then commence the paternal troubles of the male, for the young fishes, with the conceit and heedlessness natural to their time of life, immediately begin escaping from the shelter of their nest. The male, however, pursues them and drives them back by means of jets of air-bubbles, and it is not until about ten days after hatching that they are left to wander at their own will and pleasure. M. Carbonnier states that he has 520 young gouramis which were hatched in his aquarium in July last, and which at the beginning of December were from 1¼ to 2¼ inches long. He seems to hint at the possibility of acclimatizing the fish in Europe, and remarks that, among other advantages, it possesses the faculty of spawning several times in the year. —*Comptes Rendus, December* 4, 1876.

Development of Tænia inermis.—The prevalence of *Tænia inermis* at Montpellier, Cette, and Marseilles, led MM. Massé and Pourquier to endeavor to ascertain the history of that tapeworm. They administered numerous segments of the worm to two lambs, and a calf, a rabbit, and a dog. The lambs, the rabbit, and the dog did not appear to suffer from the experiment; and when killed and examined, at the end of about seven weeks, no traces of cysticerci could be found in them. The calf, on the contrary, showed symptoms of inconvenience in about a fortnight, and these increased until, two months after the administration of the joints of the tapeworm, he was in a condition that showed he could not long survive. On examining the tongue, there was found near its base on the left side a swelling about the size of a small haricot bean, under the mucous membrane. The animal was then killed, and about forty cysticerci were found in the muscles of various parts of the body, but none in the heart, brain, liver, or any of the other viscera. The cyst first observed on the tongue was nearly three-fifths of an inch long; those of the muscles were only about half this size. The cysts were clear, and allowed the heads of the future *Tæniæ* to be recognized within them; these presented the characters of *Tænia inermis*. These experiments confirm the results obtained by Leuckart, Cobbold, Enock, and Saint-Cyr,,and the author supposes that it is to the importation of cattle from Africa that the prevalence of *Tænia inermis* on the Mediterranean coasts is to be ascribed. The existence of the cysticercus in the living animal may be recognized by the presence of small tumors under the tongue.—*Les Mondes, December* 28, 1876.

COD FISHING IN NORWAY.

WHEN the old year in England has but a few hours to iive, when days are short and dark, and when we take refuge from the outer cold before cheerful fires in holly-decorated rooms —at that time very different scenes are presented in many homes in Norway. There all is vigorous activity. Men are anxiously examining and repairing fishing nets; children are disentangling and stretching fishing lines; women, more active than either, are mending leather clothes, washing woolen shirts, making large rye loaves, rolling out flat flakes of oatmeal bread as thin as wafers, watching the contents of hot ovens, and, as it were simultaneously, packing up quantities of butter, cheese, and dried meats. All this because in a few days the father and breadwinner of the family is about to depart on his annual venture as a fisherman to the Lofoten Islands. By the middle of January all is ready. The weather is then day by day carefully watched until, on the very first favorable opportunity, implements, clothes and provisions are hurried on board the fishing boat, the crew take a hasty farewell of their families, and sail away to dare stormy seas and hostile coasts.

Lofoten is the name of a group of islands extending in a southwesterly direction from 68° 36′ to 67° 25′. The channel that lies between these islands and the Norway coast is called the Westfjord; it has a wide open mouth towards the ocean in the southwest ,narrowing upwards in the opposite direction towards the northeast. The permanent population of these islands is about 25,000 souls. With the exception of a few small farms in the larger islands, only three industries are followed by the inhabitants, fish catching, fish dealing, and lodging letting; these they pursue with equal ardor. In every bay that is at all protected from the violence of Atlantic storms, the native fishermen and fish merchants have built large numbers of huts. These huts, constructed of rough boards and covered with turf, consist generally of two rooms, arranged to hold from six to twelve persons, that is, one or two crews. Round the walls of the living-room is fixed a settle or wooden bench, known as the board-bed, while in the other are stored nets, ropes, lines, clothes, provisions, and empty barrels for roe or oil. As these huts are occupied by a large number of persons, out of all proportion to their size, who moreover habitually hang up their wet and dirty clothes to dry, the air within is naturally extremely bad. But the fishermen care little for this, being well content with a hard bed and a sound roof, knowing well that less fortunate companions outside are passing the night on deep snow, with no other covering than a sail or an inverted boat. Well might these hardy mariners say, in the words of the Pilgrim Fathers, "It is not with us as with men whom small things can discourage." Early in the morning all are astir. Before going out to fish, every man partakes of hot coffee for breakfast, prepared by one of the boys. Dinner later in the day consists of dried meats with bread or potatoes, and supper of hot fresh fish or boiled fish liver with bread.

The boats engaged in fishing with nets are from 36 to 40 feet long, 9 to 10 feet wide, with a depth of not more than 3 feet. They are provided with only a single mast, about 24 feet high, carrying one large square sail. But each boat has as well ten or twelve oars, by means of which her sturdy crew can propel her against an adverse wind. For fishing with lines, smaller and less costly boats are used.

The crew, usually consisting of five men and a boy, in the first place elect one of their number to be captain. No general of any army is more strictly obeyed than is the captain of a fishing boat, for his men well know that their success, property, and often their lives, depend on prompt obedience to his orders. For these reasons in selecting a captain, experience, energy, knowledge of the channels, and coolness in danger, are alone taken into account. Age has no influence, except that no fisherman above the age of fifty is taken as captain, for he is by that time supposed to have lost something of his strength and courage. Still less does property blind the judgment, for it frequently happens that the servant is made captain while the master, who has aided the choice, has to row or work the sail. The selection once made, the captain becomes a real chief, not only over the boat at sea, but on shore over all purchases and all sales as well as before the public authorities. No sooner is a fisherman elected to be captain than his gait becomes prouder, his dress smarter, and his language more polished than before, conscious that he is raised above the common crowd. Notwithstanding his dignity, the position of captain is only one of honor, and he has no greater share in the produce of the catch than any other of the crew.

In the month of December the first shoals of cod (*Gadus Morrhua*) usually begin to appear on the western banks of the islands, arriving from the open sea. These are soon followed by great masses of fish. But as these western outside shores are shallow, the ports few, and the whole coast exposed to the frequent fury of the North Sea, not more than from six to eight hundred boats venture on the hazards of this early fishery, and their take seldom exceeds five or six millions of fish.

In the mean time the inhabitants on the inner or eastern side, protected from northerly winds, and favored with many bays of refuge, examine their shores day by day with baited hooks, to discover if the precursors of the dense shoals of cod have yet appeared in the Westfjord, and great is the public exultation when the joyful news of their arrival is announced. This important event takes place generally in the latter end of December, but not before the middle of January do the fish arrive in great masses.

On their approach, the shoals usually choose for their entrance the opening between the islands Moskö and Röst, or between Röst and Vœro, all situated at the southwest extremity of this group of islands. No sooner have they entered the Westfjord than they distribute themselves in prodigious numbers in order to select suitable places for spawning. As the area is great and the fish capricious in their choice, it is not possible for the keenest captain to foresee where the densest masses of cod will accumulate. Generally they make for the eastern and more protected shores of the islands, and for the upper end of the Fjord, but in some seasons they have been known to remain on the outside western coasts altogether.

Although the fish arrive so early in the year, spawning does not actually take place till March, and not then till late in the month. It occurs not at the bottom of the sea, as is popularly supposed, but in the middle of the water, which is made turbid by the clouds of roe and milt. At this particular time the fish are very restless and go easily into the nets.

Codfish are taken by the Lofoten fishermen by three methods: 1, with hand lines; 2, with set lines; and 3, with nets.

Hand lines, requiring small capital and producing small results, are only employed by the poorest fishermen. These are satisfied with 50 fish to each man per day, although occasionally they will capture double that number. They bait with herrings, salt or fresh, and, when these are all gone, with the roe of the fish they have caught. Sometimes when the shoals of cod are very thick and dense, the men adopt another method, also with a single line but requiring no bait. Providing themselves with a long cord armed with a large and sharp hook at its extremity, they sink it into the swarming masses below, having first attached to it a couple of feet above the hook, small fishes of tin for the purpose of attracting the cod by their glitter. The fishermen then jerk the hook sharply upwards, occasionally securing a curious fish, though cruelly wounding many others that are not taken.

Set line fishing requires larger apparatus: a boat, a crew, and from 500 to 3,000 hooks baited at once. The hooks are attached to fine snoods of hemp or cotton, which in their turn are suspended on long lines; each boat puts out at least twenty-four of these lines, every line carrying more than a hundred hooks. Set line fishing usually begins in the afternoon, but in any case only at the time and in the place prescribed by the officers appointed at each station for the purpose. The baited hooks are generally suspended near the bottom, but if there is reason to believe that the fish have risen, as they sometimes will, the lines are shortened and the bait raised to the required height by means of glass floats. They are then left all night. On the following morning the lines are taken in, and the crews are well content with an average take of 50 to 60 fish daily on each set of 120 hooks.

Net fishing requires larger capital, and is only followed by the more wealthy fishermen, who provide both nets and lines to be used according to circumstances. When the fish are fat, and especially during spawning season, they will hardly take any notice of the bait; then is the time the nets are used. Every boat carries at least 60 nets of from 10 to 20 fathoms deep. These nets are suspended in the water from floats of wood, cork, or glass. Hollow glass floats are preferred and are almost exclusively used at Lofoten, a most useful application of that water-resisting material, invented by Mr. Christopher Faye, of Bergen. Sixteen to twenty nets bound together in one length are set out in the afternoon, and, weather permitting, are taken up the following morning. A catch of from 500 to 600 cod is considered satisfactory; but if this number is largely exceeded, part are left in the nets till the afternoon, because the boats could not safely carry so heavy a freight together with the crew and wet nets.

The total take of cod by these various methods has ranged during the last few years from fifteen to twenty-five millions of fish per annum.

The cod being thus caught, the first thing the fishermen do after coming on shore is to have their dinner. That concluded, they proceed to clean and prepare their catch.

The livers reserved for the preparation of medicinal oil are all very carefully examined, and those that are poor, have sustained injury, or have portions of gall adhering, are removed. The selected are then thoroughly washed and afterwards dried. The fishermen, many of whom make the oil themselves or sell to larger makers, put these prepared livers immediately into open barrels where the oil slowly exudes, and rising to the top is removed with large spoons. It is then when quite cold filtered three or four times through filtering paper and the preparation is complete. Nothing more remains but to pour it into tin cans or oak barrels, and it is ready for market. This oil is described as of a straw yellow, has nearly no smell nor taste, and is known as "natural medicinal oil."

In the meantime other fishermen having carefully sorted, washed, and dried their livers, place them in a pot of tinned sheet iron. This tinned pot is then put into a larger iron pot half full of water, which on becoming heated causes the livers immediately to begin to give out their oil. Other makers introduce steam from a boiler between the two pots, and others let the steam act directly on the livers. The first yield by these methods of regulated heat is also removed by spoons, filtered when cold, and reserved for medicinal use, under the names of "steam-boiled medicinal" and "ordinary bright." The after yield is used in medicine, though somewhat redder: it is called "bright brown."

Finally, those portions of liver that will not dissolve by themselves or by a mild heat, are roughly boiled down to yield dark brown or tanners' oil, the black residue being used with other fish refuse for manure.

As for the fish itself, when the liver and the roe have been carefully removed, the back bone dissected out, and the entrails and head thrown into a waste heap, it is cut open down to the tail, whereby it becomes quite flat, and in that state is either packed away between layers of salt, or is hung up to dry in the cold open air till it becomes as hard as wood, to be henceforth known as—stockfish.

The cod liver oil prepared at Lofoten finds its way in the first stage of its travels to Bergen, where it begins to arrive in May. Here live the merchants who have advanced money, implements, and provisions to many of the fishermen early in the season, and who now take a lively interest in the pecuniary results. Many of the fishermen require no advance, and these sell their produce to the highest bidder. The care taken at Lofoten in preparing the medicinal oil is by no means extended to the dark brown or tanners' oil. This is made all along the coast indiscriminately from the livers of cod, coal-fish, ling, tusk, halibut, haddock, skate, and even of the shark. But before exportation every barrel is examined by an official expert at Bergen, who, with an iron instrument, makes a mark close to the bung indicating the quality.

Early in April the fish begin to leave the Westfjord, and soon after retire towards the open sea in such multitudes that by the end of the month both fish and fishermen have departed; the fishers' huts, so lately swarming with life, are silent and empty, and the Lofoten Islands are left to their permanent inhabitants for the remainder of the year.

Five years ago the number of men engaged in these fisheries exceeded 27,000, owning more than 4,000 vessels. In contrasting this amount of labor with its results—fifteen to twenty-five millions of cod fish—it should be remembered that the tempestuous weather usually prevailing in these northern latitudes during the winter months often prevents the fishermen going to sea for weeks together, and that a season that has permitted fishing on an average of two days a week may be considered a favorable one.

Although the cod fisheries of Lofoten are the largest and the most renowned, Norway has many others of great value along her far-stretching sea-board. Opposite the Throndhjem Fjord, and from that to Cape Stat, there are three or four miles from the shore several very rich fishing banks, where cod collect in enormous shoals to spawn, observing the same periods as the Westfjord fish. Again, opposite the Varanger Fjord, from the 59th to the 62d parallel latitude, are many good cod banks. From Aalesund now annually go forth daring crews with decked vessels, who fish in the deep sea at a distance of ten or twelve miles from the shore. Their lines are set on a bank at a depth below the surface of from 150 to 200 fathoms, that is to say, from four to six times the height of the London Monument. Exceeding these in importance is a relatively new fishery in the far north in Finmark, which now promises to rival even that of Lofoten itself in its yield. In the latter part of February the appearance of millions of sea-gulls fluttering along the surface of the ocean, with the spouting and blowing of numerous whales in it, announce to the scanty population of Finmark and Cape North, that great shoals of capelin (*Mallotus villosus, Osmerus arcticus*) are approaching the shore. Following these, it is well known, will also be millions of cod fish pursuing their favorite food. So valuable has this fishery become that many of the men after finishing the Lofoten season, now flock to Finmark, and have lately succeeded in taking an after catch of from twelve to fifteen millions of fish. In this enterprise they are favored by the later migration of the northern shoals, which always continue on those shores till the end of May, and in the Varanger Fjord until June. But in Finmark the harbors are bad and the weather more violent and destructive than in Lofoten; were it not for this the take would be much larger than it is, as the shoals of fish in Finmark appear to rival those of Lofoten in magnitude.

Thus the Norwegian fisheries produce in great abundance not only an invaluable remedy for one of the most fatal maladies that afflicts humanity, but they supply many tons of wholesome and cheap food to the less affluent populations of the whole of Europe. These industries result in a hardy earned income to these hardy Northmen of not less than £2,500,000 per annum, a magnificent sum for a country possessing a population of barely two million of souls.

The facts in the preceding paper have been gathered by Mr. Robert Howden from an official report, by Mr. Hermann Baars, of Bergen, written originally in the German language; this report was translated into English by Mr Alfred Sharpe, of Christiania, for the purpose of explaining the same industries at the Philadelphia Exhibition last year. Mr. Baars is a gentleman of intelligence and high culture. He is in no way connected with either pharmacy or commerce, so that his object has been not to inform pharmacists, or any other class, so much as to make a general report on the National Industries of his country. From this work the above particulars have been gleaned; if on the one hand we may regret the absence of some technical details, on the other we are largely indebted to him for much new and exact information that is now, through his intelligent industry, submitted to the reader.—*Pharmaceutical Journal.*

[NATURE.]

NOTES.

Electrical Eels.—Three electric eels from the River Amazon have lately been added to the Westminster Aquarium, London. As they require to be kept at a temperature of between 70° and 80° F., it needed some ingenuity to bring them from Liverpool, where they were landed, to London. By placing the vessel containing them on foot warmers, and telegraphing on for changes of foot warmers at different stations, the water on arriving at Westminster was found to be at 75°. The eels are lodged in a tank kept warm by a steam pipe passing under the shingle, and are at present by the alligators. These, by the bye, are waking up wonderfully in activity, and the attendants have now to keep a sharp lookout when cleaning the tank.

Antiquities of Nicaragua.—Dr. J. F. Bransford, surgeon in the United States Navy, has been investigating the antiquities on the island of Omotepe, in Lake Nicaragua, collecting large number of vases of various kinds, burial urns, orna-

ments, and other objects for the National Museum at Washington. Among the more important points substantiated by him was the occurrence on the island of, at least, three successive and distinct bases of prehistoric civilization, all of them anterior to the present epoch, these being bounded and defined by successive overflows of lava, from the volcano. Very great intervals of time elapsed between the eruptions, as is shown by the accumulations of soil that took place on the fresh surface of the lava from the decomposition of vegetable deposits. No estimate can be made of these eras, but they are believed to carry the period of the earliest overflows back to a very remote antiquity. The objects of these successive layers are very definite and easily recognizable by the practised eye, and highly important deductions in regard to the early civilization of that region are expected from a critical investigation of the subject. Dr. Bransford has prepared an elaborate report on this subject for presentation to the Navy Department, but, before publishing it, he has obtained permission to revisit the country, and settle some still doubtful points.

A Boiler with an Open Bottom.—At a recent meeting of the French Academy, M. de Romilly called attention to some remarkable effects obtained by suspension of water sucked up into a bell jar closed below by a tissue with wide meshes; in one arrangement, the net being metallic, the suspended water could even be boiled by heat applied below. M. Plateau has just pointed out that he described this phenomenon of suspension in 1867, in treating of the construction of aquatic arachnida.

Do Toads Eat Bees?—*Apropos* of the question (which has been disputed) whether toads eat bees, M. Brunet states, in *La Nature*, that going one day into his garden, just before a storm, he found the bees crowding into their hives. About fifty centimeters from the best hive there was a middle-sized toad, which every now and again rose on his fore legs and made a dart with surprising quickness towards blades of grass. He was found to be devouring bees, which rested on the grass blades, awaiting their chance to enter the hive. M. Brunet watched till twelve victims had been devoured; he expected the toad's voracity would soon be punished with a sting, but in vain. Objecting to further destruction, he seized the toad by one of his legs and carried him to a bed of cabbage thirty meters off, where he might do real service among the caterpillars, etc. Three days after this, on going out to the hives, he found the same toad (which was easily distinguishable) at its old work. M. Brunet let him swallow only three or four bees, then carried him fifty meters in another direction. Two days later the "wretch" was again found at his post, greedily devouring.

ACROSS AFRICA.

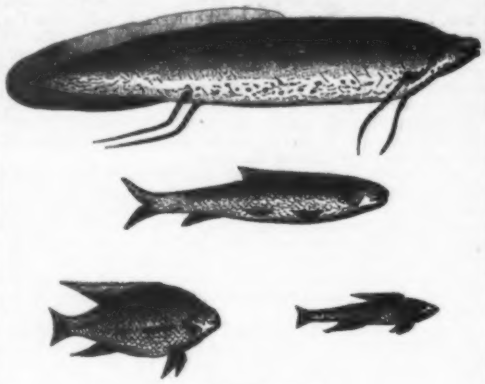
OUR readers are, no doubt, already familiar with the main results of Commander Cameron's remarkable march across the continent of Africa; many details concerning it have appeared through various channels. These, however, have only been sufficient to whet the appetite of all who take an interest in African exploration for the complete narrative; this we find quite as interesting and informing as we had reason to believe it would be. Commander Cameron has not attempted to produce a highly polished summary of the copious notes he seems to have taken by the way; he takes the reader along with him step by step and day by day over the long and, to him, often tedious route he had to travel, and in the end the reader finds he has become possessed of a substantial amount of new information concerning one of the most important sections of one of the most interesting continents.

Commander Cameron's story is so well known that to summarize it here would merely be to repeat what we have already given on various occasions. The primary object of the expedition which he commanded, it will be remembered, was to seek and succor the great Livingstone, whom Stanley had just discovered, after the explorer had been hidden in the center of Africa for five or six years. Cameron as leader, with Dr. Dillon, Lieut. Murphy, and poor young Moffatt, who had sold his all to enable him to find and help his uncle, set out from Bagamoyo with a large following, early in 1873. They had only got as far as Unyanyembé in October when they were sadly surprised by the bearers of Livingstone's remains, the great traveler having died in the previous May on the south of Lake Bangweolo, almost on the same day as his enthusiastic nephew perished on the threshold of his search for his uncle. Under the new circumstances Lieut. Murphy decided to return, Dillon was compelled by the state of his health to accompany him, and Cameron resolved to proceed alone to take up and continue the work

HEADS OF MEN OF MANYUÉMA.

of his immortal predecessor. By doing so, he rightly believed he was carrying out the spirit of his instructions. Dillon's sad end, a few days after he left Cameron, is already known to all.

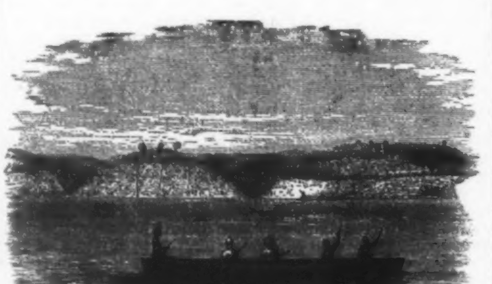
Cameron's route may be divided into four sections. First, from the coast to Ujiji; second, the survey of Lake Tanganyika; third, his journey to Nyangwé, on the banks of the broad Lualaba; and fourth, from Nyangwé, south and west, to the west coast. The first part of this route is already, to a considerable extent, familiar to those who have read the narratives of Burton, Speke, and Stanley. Nevertheless, it will be found that Commander Cameron has added considerably to our knowledge of its appearance, its products, and its people. The admirable series of levels which he was able to take from first to last, and the results of which are condensed in the section that accompanies his interesting map, shows that the ground rises till about the thirty-fourth degree west, when it slowly slopes to the center of the continent, which is a wide hollow or basin, rising very gradually towards the western coast, on which side the descent is very steep. The country between the coast is varied in



TANGANYIKA FISHES.

character, sometimes level, and sometimes very hilly, frequently swampy and liable to be inundated by the overflow of the numerous rivers which water it, but very often well wooded, thickly populated, and fertile. It is cut up into a number of States inhabited by various small tribes independent of each other, the appearance, manners, and customs of which are frequently referred to by Commander Cameron. Of the Wanyamwesi, especially, he has much to say, for at Unyanyembé, in their territory, he was detained for many weeks by fever, and indeed did not reach Ujiji till February, 1874, after innumerable troubles caused by his scratch lot of followers, and being fleeced at every hand by the chiefs through whose villages he had to pass.

Cameron was well received and well treated by the Arab traders at Kawelé, the capital of Ujiji, and here he fortunately secured Livingstone's papers. After measuring a short base line, he set out, on March 13, to circumnavigate the southern half of Lake Tanganyika. Our readers will remember that Burton and Speke were able to survey a comparatively small portion of the lake in the neighborhood of Ujiji, while Livingstone and Stanley coasted the east side of the northern part, and a portion of the northwest coast. Cameron has, therefore, by his survey been able to add considerably to our knowledge of this interesting lake. He sailed along the eastern side of the southern half, crossed to the west just before reaching the end of the lake, passed up the west side, examined the Lukuga, and returned to Ujiji on May 9. His work contains a great deal of information as to the result of this survey, and he has been able to lay



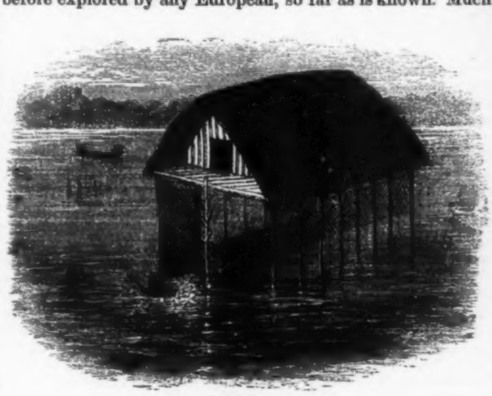
NYANGWÉ FROM THE RIVER.

down, we have no doubt, with considerable accuracy, the contour of the shores. These are mostly high and rocky, covered with trees and other vegetation, often fringed with dense reeds, and cut up by a multitude of streams. Animal life of all kinds, quadrupeds, birds, insects, fishes, abounds around and in the lake, the scenery of which Cameron describes as of surpassing beauty. The western shores are well peopled by a fairly industrious population, but many portions of the east coast have been devastated by slave-hunters, evidences of whose destructive raids were seen all along Cameron's route. With regard to the river Lukugu, which Cameron believes to be the outlet of Lake Tanganyika, and an affluent of the Lualaba, he has some interesting notes. He believes he traced a distinct current westwards, and sailed up several miles until stopped by a dense barrier of vegetation which crossed from side to side. As we said, when referring to this point previously, we do not think much is to be gained by discussing the question in its present shape. It is not as if no further data were to be obtained, the question is one capable of demonstration by the attainment of additional information, and we hope that Mr. Stanley will be able to set it at rest as satisfactorily as he has settled the contour of the Victoria Nyanza. To Cameron, geographers are greatly indebted for the large additions he has made to a knowledge of Lake Tanganyika.

About a fortnight after his return from this survey—which, we ought to say, was carried out amidst innumerable difficulties caused by the timidity and inefficiency of his crews—Cameron crossed the lake to make for Nyangwé in the hope of obtaining boats to take him down the Lualaba. He passed over pretty much the same route as did Livingstone, whose memory he still found alive among the people. The two main districts in this route are Ugubha and Manyuema, and the people are among the most interesting with whom Cameron came in contact. In Uguhha copper is largely worked, and shaped into curious cross-bars, and in Manyuema iron ore is found and largely smelted in elaborately and ingeniously constructed furnaces. The people of Manyuema are in many respects peculiar, and although undoubted cannibals, superior to the tribes around them. Cameron believes them to be a superior intrusive race, the lower classes being aborigines. They live in well-built houses, arranged in neat villages, and are of fine physique. They seem well deserving of further study.

At Nyangwé Cameron was well treated by an old Arab who had been kind to Livingstone, but to his great disappointment he failed in obtaining boats to carry out his cherished purpose. He was assured by many people, both here and in his journey southwards, that the Lualaba, a fine broad stream at Nyangwé, flowed westwards into a large lake, Sankorra, to which men came in large boats capable of holding 200 people, for the purpose of trading. From the interesting data collected by Cameron we must say that he has good reason for connecting the Lualaba with the Congo, and regarding the latter as the great drainer of all the region to the west and northwest of Tanganyika. The Lualaba is in the very lowest part of the great Central African basin, is a river of very large volume, which, in the upper part of its course, receives various affluents, and it is difficult to conceive what other southwest African river except the Congo could carry off all this drainage. Still there is an extensive region, from about 5° N. to 10° S., waiting to be explored, and until this is done we think it premature and unnecessary to maintain any positive theory on the subject. The solution cannot now be far off with so many expeditions either on the field or about to be sent out. The data obtained by Commander Cameron are of great value, and will form an important guide to subsequent explorers.

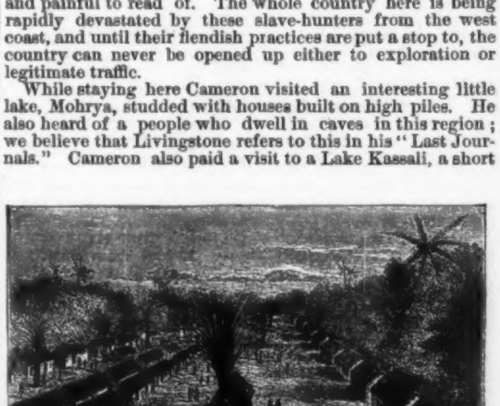
In company with an Arab trader, Cameron proceeded southwards in the hope of being able to work his way north to Lake Sankorra. In this, too, alas, he was grievously disappointed, his designs being thwarted on every hand by the caprices of besotted chiefs and brutal slave hunters, and the cowardly fears of his own men. The greater part of the ground from Nyangwé to the coast region, southwest, over which Cameron now traveled, is quite new, never having been before explored by any European, so far as is known. Much



HUT IN LAKE MOHRYA.

of the second volume, on this account, possesses novel interest. Most of the country is fertile, well watered, and well wooded. Innumerable streams were crossed, and so level is the watershed between the streams going east and those going west, that during floods, which seem to be frequent, their courses must sometimes be changed. About 200 miles south of Nyangwé, Cameron came to Kilemba, the headquarters of Kasongo, the chief of the extensive district of Urua, and where is the principal station of the remarkable Arab trader, Jumah Amerikani. This individual has extensive trading connections over Central Africa, is a man of considerable intelligence, and was able to give Cameron much geographical information which he had gathered during his widespread journeys. Cameron was compelled to remain at Kilemba for about eight months, and had it not been for the ever-to-be-remembered kindness of this humane and generous Arab trader, his life must have been intolerable, even if he had been able to preserve it. The treatment of Cameron by this remarkable man is beyond all praise. Cameron found at Kilemba a black slave-hunter from the Portuguese settlements, than whom probably a more barbarous blackguard does not exist. The cruelties practised by this man and the chief Kasongo are almost incredible and painful to read of. The whole country here is being rapidly devastated by these slave-hunters from the west coast, and until their fiendish practices are put a stop to, the country can never be opened up either to exploration or legitimate traffic.

While staying here Cameron visited an interesting little lake, Mohrya, studded with houses built on high piles. He also heard of a people who dwell in caves in this region; we believe that Livingstone refers to this in his "Last Journals." Cameron also paid a visit to a Lake Kassali, a short



VILLAGE IN MANYUÉMA.

distance south of Kilemba, and which contains many floating islands; but he was not permitted to reach the shores. He has collected much interesting information about the people among whom he was compelled to sojourn, and collected many notes from various sources concerning the geography of the region. But the capricious restrictions under which he was placed compelled him to lead a life of comparative idleness, so that when Kendele, the brutal slave-hunter, whose pleasure he was compelled to await, was ready to march with his ill-gotten human booty, the wearied traveler was heartily glad. This was in June, 1875, and starved and nearly dead with scurvy he reached Benguella in November.—*Nature.*